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The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-fifth Year of Continuous Publication

VOL. LXXII

JULY, 1946

NUMBER ONE

Editorial

MANAGEMENT OF ADVANCED CANCER*

IN stressing the need for the intelligent treatment of advanced cancer, we accomplish a dual purpose: In the first place, we guarantee, measurably, the better treatment of a group of patients so deplorably in need of help; and in the second place, we broaden our knowledge of the disease. It has been stressed so emphatically and so frequently, of late, that more intensive research offers the largest measure of hope of conquering the ogre cancer, that this truth does not have to be emphasized. What may be mentioned with profit, however, is the fact that clinical research and laboratory studies are, or, if they are not, should be inseparable handmaidens. In the field of clinical research, the advanced cases of cancer constitute a veritable gold mine of still unexplored possibilities. Peripheral spread, regional and remote metastases, variations in the duration and course of the disease, dependent upon organs involved, or upon diet, or constitution or genetic background, the riddle of cachexia, these and many other unsolved puzzles may be studied with the greatest possible advantage in patients suffering from advanced cancer.

In order to avoid confusion of mind and consequent snarled thinking, one ought to establish, at the outset, what we mean by

"advanced cancer." We may elect to regard the phrase as signifying progress of the disease to the point where, due to the size of the tumor, extensive ulceration, lymph node involvement, duration of the illness, or incapacity of the patient, it is perfectly clear that the disease, although in the advanced stage of its development, is nevertheless still operable; or we may elect to deal only with that type of advanced cancer in which, owing to the advanced state of the disease, it has become inoperable.

This paper limits itself to that group of patients who have emerged from the status of operative cure into the unfortunate plight of inoperability. It is both reasonable and justifiable to frame our thoughts with such narrow limits; because if we elected to include operable cancer, the discussion naturally would be diverted into channels of method and technic of applying that treatment. Such a discussion, covering the whole field of various types of cancer, invading various tissues and organs, might prove to be too wide in scope. On the other hand, limiting the field strictly to a consideration of advanced, inoperable cancers furnishes an opportunity for discussing a group of patients

* From the Department of Pathology, The Barnard Free Skin and Cancer Hospital, St. Louis, Missouri. Read at the Sectional Meeting of the American College of Surgeons, St. Louis, Mo., January 31, 1946.

who are, literally, the flotsam and jetsam in this particular realm of surgery.

At the very outset, we may lay down two fundamental propositions: (1) There are patients with cancer who are beyond the scope of surgical cure. If these patients, as a result of undue surgical zeal, are subjected to radical operative attack they may be compromised even in excess of the disability and suffering incident to the disease untreated. (2) There are at the command of surgeons, tried and proved measures of palliation in cancer that may be practiced with such happy results as to be satisfying both to the intelligence and the conscience of the surgeon, even though they offer not a glimmer of hope of cure.

There may be, and there frequently is, a rather narrow dividing line between the indications and the contraindications to radical surgery; but this is a common situation in the field of surgery in general and calls for no special comment. Then too, there is a partial shadow zone in which it is difficult to support conviction by action. For example, I should never counsel radical breast amputation in the presence of supraclavicular lymph node metastasis; but I have never been in unqualified disagreement with, or even mildly condemnatory of a competent surgeon who, in a given instance, elected to differ with me on this point. I, myself, do not find it possible to agree with all evidences of inoperability in cancer of breast as set down by Haagensen and Stout,* although in general, I concur in the concepts that they set down regarding inoperability. The point is that universal and unalterable postulates cannot be established.

But we may emphatically reject those judgments which underlie massive cervical lymph node resections in undeniably inoperable patients; or jaw resections in those patients who will face an almost inevitably dismal future horribly deformed, dripping saliva and unable to eat or drink with even the remnant of comfort that was

theirs before treatment; or radical rectal resections with scattered mesenteric lymph node enlargements plus a solitary metastasis in the liver. Such surgical exercises as these do not constitute malpractice in the legal sense; they are not evidences of surgical misconduct, but they represent what may fairly be interpreted as overaction on the part of surgeons goaded by the combination of fear, horror and despair incident to the chapter of cancer in general and to advanced cancer in particular.

The objections herein voiced are not based on the mere performance of unduly radical operations; but rather on the uselessness, even the harmfulness of fruitless surgery. No procedure is to be condemned on the mere fact that it is radical. The sole criterion must be the probable degree of help or surcease that may be afforded the patient. To lop off a leg or an arm, useless and painful from inordinate lymphedema, or pathological fracture; to perform the operation of a simple mastectomy for a foul, fungating, malignant ulcer redolent with stench; to make any of the various ostomies for inoperable cancer of the gastrointestinal tract; to decompress the brain for relief of pain or approaching blindness, all of these palliative procedures should, on any count, have the blessing of deity and man, because they are planned to lighten the load and the lot of individuals descending the path of distress and pain, into the valley of oblivion.

There is one hazard—a purely psychological one—incident to withholding surgical aid from the inoperable cancer victim. The patient of average intelligence afflicted with advanced cancer is suspicious of his plight in a large percentage of instances. He clings avidly to Pandora's box, the lid of which he clutches closed lest hope itself, his one remaining asset, should escape. When the surgeon refuses operative interference, the patient almost inevitably concludes that he is beyond physical salvation; and unless he be a philosopher in the truest sense of the word, he begins to sink into a slough of despond-

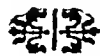
* HAAGENSEN, C. D. and STOUT, A. P. Carcinoma of the breast. *Ann. Surg.*, 118: 859, 1943.

ency. A resourceful surgeon knows how to correct this mental ill; and I for one am all for correcting it even at the sacrifice of dalliance with truth. Many ruggedly honest but humanly minded surgeons who have champed all the chaff about telling the patient "the truth, the whole truth and nothing but the truth" still believe, with Emerson that "God offers to every mind its choice between truth and repose. Take which you please, you can never have both."

The gospel of surgical conversatism in the treatment of advanced cancer does not warrant the conclusion or even the inference that a policy of *laissez faire* must be the order of the day. A great deal can be done to alleviate the advanced cancer victim. The intelligent application of radiotherapy, for example, can accomplish much in selected cases, both in checking the advance of the growth of the tumor and in subduing pain; particularly is this true in cases of skeletal metastases with intolerable pain; but also, on occasion one sees severe pain subdued by radiotherapy in cases of inoperable abdominal carcinoma. In extensive surface ulcerations that are heavily infected and actively suppurating, the newer antiseptics, sulfa drugs and penicillin, may lessen both discharge and odor. At times the cautery

serves the same or better purpose. Iodoform, charcoal and in particular, acetone, are occasionally useful in the same way. Castration, by actual gonadectomy in male and female, or by radiotherapy in the female or by hormonal therapy in either sex, furnishes a new technic that, in some instances, such as prostatic and mammary cancer with remote and particularly with skeletal metastases, is followed, not infrequently, by results that are almost incredible. And finally, there are the alkaloïds of opium. The patient in the advanced stages of cancer has the first claim on DeQuincey's thought, "Thou hast the keys of Paradise, O just, subtle and mighty opium!" In the last analysis, it is the sheet anchor against the agonal tragedies of cancer. And I lean more and more toward the idea of even freer use of this drug, earlier in the disease than I formerly administered it. I fear less and less the bug-bear of an acquired immunity, and I have come more and more to believe that the necessary and inevitable increase of dosage brings with it a subtle sort of synergistic drug toxemia that induced an earlier end to what is probably the most tragic of all other of Nature's cat and mouse tragedies.

M. G. SEELIG, M.D.



Original Articles

SURGICAL TREATMENT OF JEJUNAL ULCER*

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THE physiologic consequences of gastrojejunal anastomosis range from triumph to tragedy, and afford the surgeon a few of his finer moments and some of his greatest grief. Performed primarily for the relief of the most unresponsive types of duodenal ulcer, the procedure of gastro-enterostomy is followed not infrequently by jejunal ulceration, a lesion more intractable, more disabling and more subject to serious complication than primary gastroduodenal ulcer. This distressing consequence of the artificial gastro-enteric stoma has brought disfavor to the procedure of simple gastro-enterostomy and a measure of disappointment to the advocates of partial gastrectomy as a means of avoiding this complication of the surgical treatment of peptic ulcer.

INCIDENCE

The incidence of jejunal ulceration following gastro-enterostomy is variously quoted from 1.7 to 34 per cent.¹ Such a wide discrepancy is difficult to analyze and impossible to reconcile, but we believe that Lahey's estimate of an incidence of 15 per cent is a reasonable approximation of the true figure. Essentially a complication of the surgical treatment of duodenal ulcer, it is rarely encountered following gastro-enterostomy performed for the relief of gastric ulcer or carcinoma. That the frequency of secondary ulceration following partial gastrectomy is considerably less than after simple gastro-enterostomy is generally accepted. The recorded incidence from resection varies between 0.5 and 10.0 per cent.

LOCATION

The descriptive term, marginal ulcer, while occasionally accurate, is, in the broader sense, a misnomer; for the majority of these ulcers are situated entirely within the jejunum, either opposite the stoma or in the efferent region, a few centimeters distal to the anastomosis. The afferent loop is singularly immune to ulceration. It is believed that marginal ulcers begin as jejunal lesions and spread by peripheral expansion to involve the gastric mucosa. In a series of ten patients operated upon in the Henry Ford Hospital during the past year for "marginal ulcer" nine of them had their lesion entirely within the jejunum, and only one patient demonstrated involvement of the gastric mucosa, and even this ulcer was essentially jejunal in location. In no instance was the afferent loop affected.

The location is significant. First, it reflects the increased sensitivity of jejunal mucosa to gastric secretion, and secondly, it demonstrates the beneficent rôle that the alkaline contents of the duodenum play in protecting the afferent region from erosion. In view of the predominant location of these lesions it would be more accurate to call them either jejunal or anastomotic ulcers, as suggested by Marshall.³

ETIOLOGY

The definitive etiology of jejunal ulcers is unknown in the same fundamental sense that the cause of gastroduodenal ulceration is still a mystery. There are, nevertheless, some factors which are present with such consistency as to gain widespread accept-

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ance as causative agents. Foremost among these are the three emphasized by Ochsner; (1) an inherited constitutional predisposi-

subsequent trouble, and, if subjected to surgery, is perhaps less likely to have an entirely satisfactory result than is the ulcer

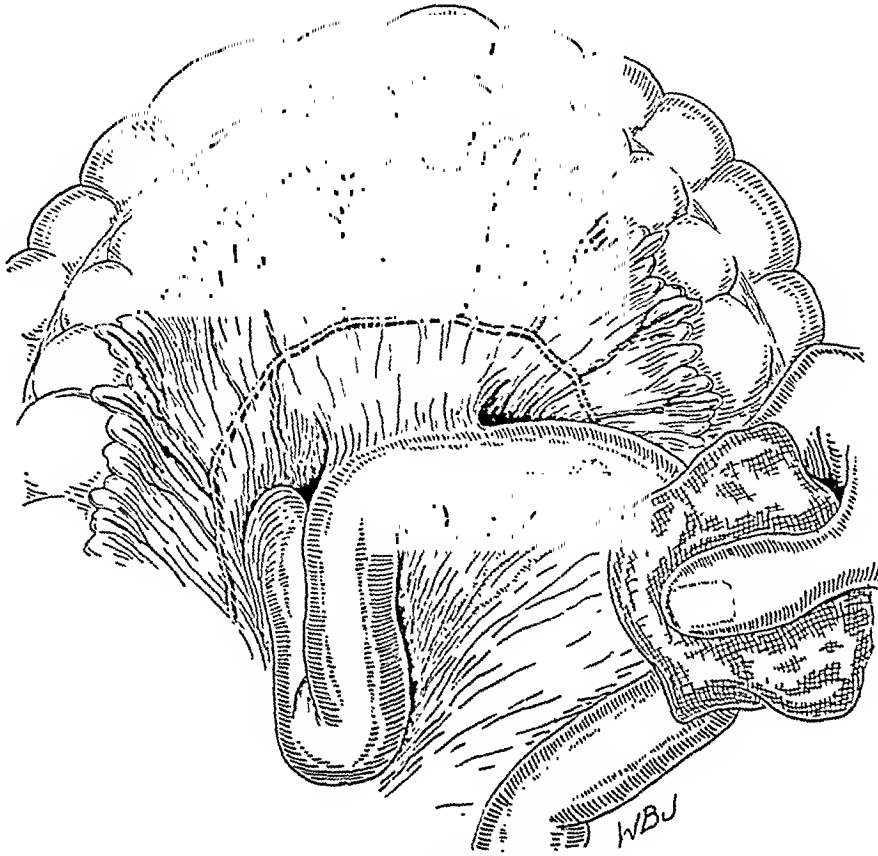


FIG. 1. Jejunal ulcer distal to gastrojejunostomy stoma. Note induration extending into the mesentery.

tion to form ulcers, (2) a tissue susceptibility to ulceration, and (3) an increased acidity of gastric contents.

The first is fundamental but immeasurable. The patients who develop jejunal ulcers are, as Walters and Claggert⁴ so aptly designate them, "ulcer formers." They are a select, if unenviable, group in the sense that their original ulcers were persistently severe and unresponsive to medical management. They are further distinguished by virtue of their previous record of frequent and threatening complications of their initial peptic lesion, such as massive hemorrhage and free perforation.

The theory that rupture of a gastroduodenal ulcer bestowed some curious protection upon the victim with respect to future difficulty has been largely discredited. The patient who has a perforation of a gastroduodenal ulcer is prone to have

patient who has not experienced this difficulty. It is interesting, if not statistically significant, to observe that one-third of the patients upon whom we have operated for jejunal ulcer have had a previous perforation of a gastroduodenal ulcer.

Furthermore, the patient who suffers a rupture of a postoperative jejunal ulcer will have had, in many instances, a former perforation of a gastroduodenal lesion. While multiple perforations of a primary peptic ulcer are relatively rare, jejunal ulcers are more subject to recurrent rupture. It would appear that some patients exhibit not only an ulcer forming diathesis, but equally important a perforative tendency.

It is an easily demonstrable fact that tissue sensitivity of the intestinal mucosa to gastric secretions increases in direct proportion to its distance from the pylorus. Thus patients who, as a result of surgical

error, have had a gastro-ileostomy will have, in many instances, ileitis or ileal ulceration.⁵ But above and beyond this

and the mechanical trauma from the impingement of the gastric chyme on jejunal mucosa in the production of post-

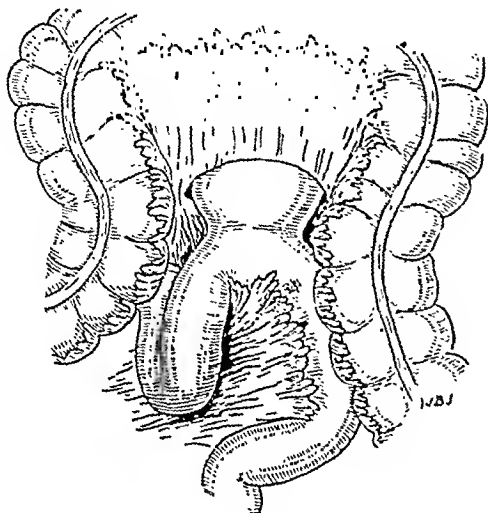


FIG. 2. Mesocolon detached from anastomotic area.

usual sensitivity, the jejunal ulcer victim exhibits an increased intolerance to the presence of undiluted gastric secretion in the small bowel.

The importance of increased acidity of gastric contents as an etiologic determinant is generally conceded. This contention is supported by the fact that postoperative ulcers are rarely seen in the absence of excessive acid values. They are practically unknown following gastro-enterostomy or gastrectomy for ulcer or carcinoma of the stomach, and they almost never involve the afferent loop because of the presence of the highly alkaline duodenal contents. The superiority of gastrectomy over gastro-enterostomy in the surgical treatment of duodenal ulcer is predicated essentially upon the fact that the more radical resection significantly lowers the postoperative acid value. The failures of this procedure can usually be traced to its inability to reduce gastric acidity consistently and permanently.

The rôle of surgical technic, non-absorbable suture material, intestinal clamps

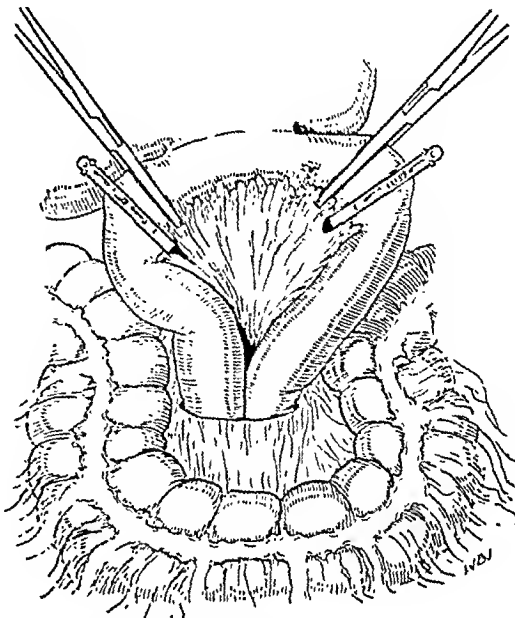


FIG. 3. Retraction of anastomotic area with afferent and efferent loops of jejunum into supracolic compartment. Clamps applied preparatory to resection.

operative ulcer was once thought to be considerable, but now is regarded as relatively unimportant.

The tendency of anastomotic ulcers to occur predominantly in the male is even more pronounced than in gastroduodenal ulceration. Nine of our ten patients were men. This fact is consistent with the observation that peptic ulcer, in addition to being less common in females, is better tolerated by them.

Jejunal ulcers commonly affect the young. Approximately one-half of our patients were under thirty-five years of age and only two were over fifty-five.

In general, postoperative jejunal ulcers occur in young adult males who have had a gastro-enterostomy for the relief of a duodenal ulcer that had been the site of one or more serious complications, and in whom the surgical procedure had been followed by a persistently high gastric acidity.

SYMPTOMS

The symptoms of jejunal ulceration are not unlike those of primary gastroduodenal

indication of the presence of a jejunal ulcer, and, as a general rule, bleeding which occurs some time after gastro-enterostomy

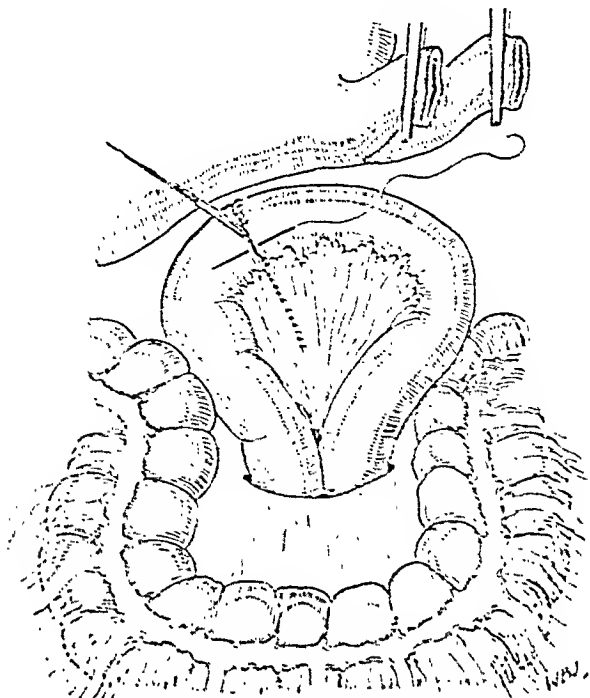


FIG. 4. End-to-end anastomosis of jejunum restores intestinal continuity.

ulcer and still are not identical. The pain is gnawing and burning in character, but it is located to the left of the midline about the level of the umbilicus instead of being in the epigastrium. It is less rhythmic than primary ulcer pain and considerably less responsive in both a symptomatic and strict therapeutic sense to the ingestion of selected foods and alkali.

Like gastroduodenal ulcers, jejunal erosion may occur and, indeed, progress to serious complications with surprisingly few digestive symptoms. One of our patients, whose anastomatic ulcer perforated, was awakened by excruciating pain indicative of rupture without having had any prodromal symptoms suggestive of recurrent ulceration. But in general the pain is more severe, more chronic and more diffuse than primary ulcer distress.

COMPLICATIONS

The serious complications of jejunal ulcer are hemorrhage, free perforation and gastrojejunal fistula.

Massive hemorrhage may be the first

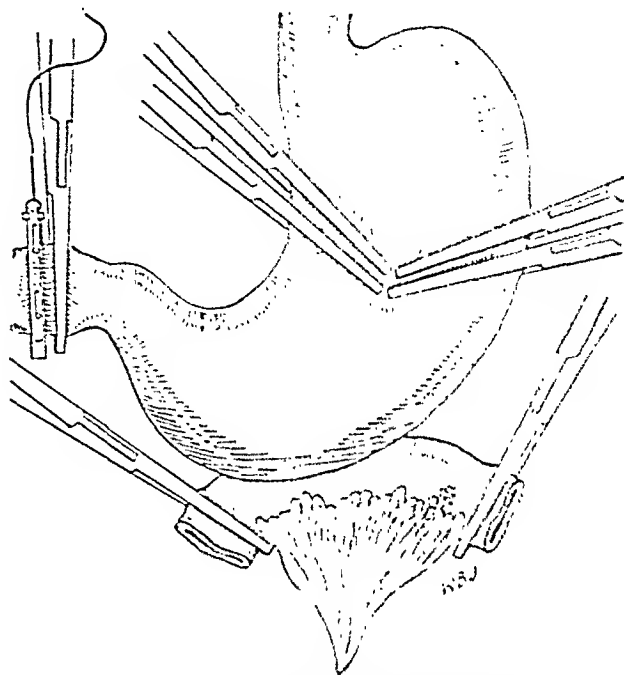


FIG. 5. Stomach and duodenum mobilized for resection. Note angle at which gastric clamps are applied.

is due to an anastomatic lesion rather than to reactivation of a primary peptic ulcer.

Perforation of jejunal ulcers is rare in the sense that only a small number have been observed and recorded, but it is a relatively common complication among patients who have jejunal ulcers. Bracci,⁶ in 1937, collected approximately 200 cases from the literature.

Singer and Meyer⁷ pointed out the perforative tendency in patients who had experienced rupture of a jejunal ulcer and also emphasized the predisposition to recurrent perforation. In a patient presenting evidence of a ruptured ulcer following gastro-enterostomy or gastric resection, the lesion will be found, almost invariably, in an anastomatic ulcer, and, in a majority of cases, the victim will have had a previous perforation of a gastroduodenal ulcer. We have observed four perforations in three patients, two of whom had suffered an earlier rupture of a primary peptic lesion.⁸

The problem of gastrojejunal fistula will not be considered in this presentation.

DIAGNOSIS

Confirmatory x-ray diagnostic evidence is often wanting, especially when the ulcers are situated in the efferent loop

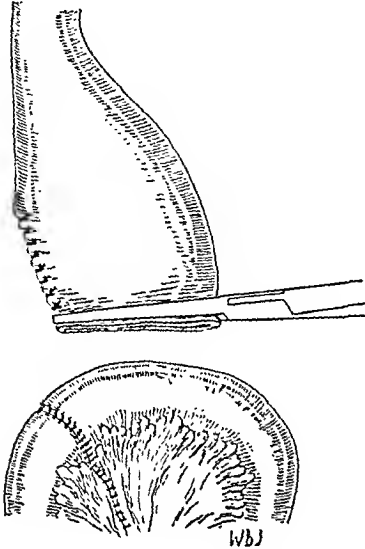


FIG. 6. Tube-like appearance of remainder of stomach after closure of the upper portion. Spleen and short gastric arteries are not depicted.

of jejunum at some distance from the stoma. Recognition of these ulcers then necessarily has to be based on clinical grounds. Though some jejunal ulcers are silent until manifested by perforation or hemorrhage, recurrence of ulcer symptoms after operation is *prima facie* evidence of jejunal ulcer.

TREATMENT

Intensive medical therapy is tried in almost every instance of jejunal ulceration, but the response is generally poor, and most of the victims are subjected to surgery without undue delay.

Preoperative Preparation. In addition to the usual preoperative preparation for gastric resection, it is important to cleanse the colon thoroughly before operation because the jejunal ulcer may be adherent to the colon, and in the process of separation this viscus also may be inadvertently

entered. Blood should be drawn from at least two cross matched donors since the operation is time consuming, and the patient requires protection against shock.

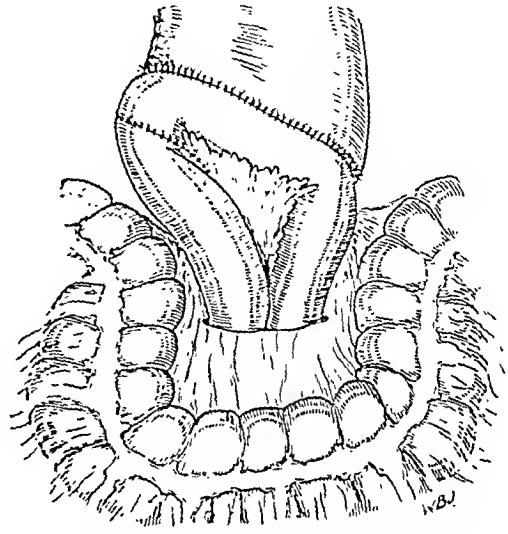


FIG. 7. Retrocolic isoperistaltic anastomosis completed.

Operative Technic. Under nupercaine 1-1500 or continuous spinal anesthesia the scar of the previous upper abdominal incision is excised and the abdominal cavity is entered preferably through the linea alba. The great omentum is freed from its attachment to the anterior abdominal wall in order to mobilize the transverse colon and any other abdominal adhesions are separated. The duodenum is next inspected for evidence of reactivation of the original ulcer though we have not found the coexistence of an active duodenal ulcer and a jejunal ulcer in any of our patients. The transverse colon is now elevated into the wound to allow for investigation of the stoma and the efferent loop of jejunum. Chronic ulceration of the jejunum manifests itself by induration and thickening of the involved area which in our experience is situated on the efferent loop either opposite the stoma or as far distally as 10 cm. The area of ulceration usually is close to the mesenteric border so that the accompanying induration extends into the mesentery. (Fig. 1.)

The first step, except in those cases in which an ante-colic anastomosis has been made, is to detach the transverse mesocolon

held out of the way while continuity of the jejunum is being restored by an end-to-end closed anastomosis. (Fig. 4.) This

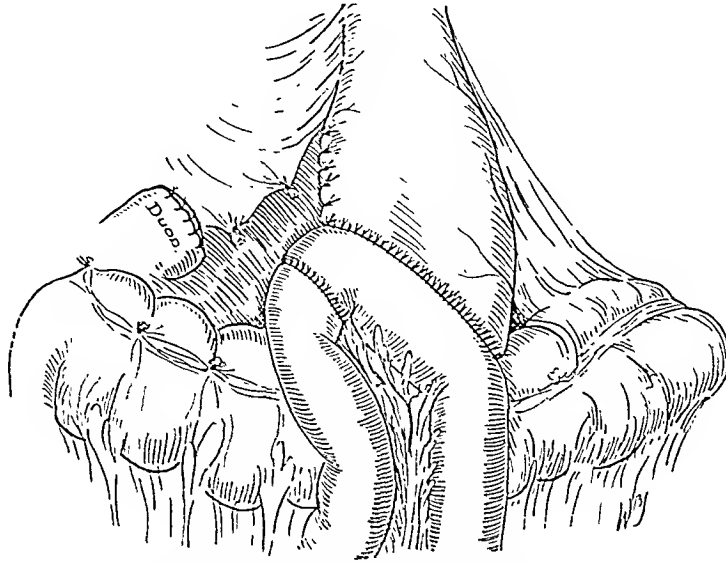


FIG. 8. Antecolic anastomosis indicated for recurrent jejunal ulcers and for ulcers appearing after partial gastrectomy.

from the anastomotic area exercising great care not to injure the middle colic artery. (Fig. 2.) The gastrocolic omentum is then sectioned to permit retraction of the anastomosis and the involved area of jejunum into the supracolic compartment. (Fig. 3.) We have found that resection of the segment of jejunum containing both the anastomotic site and the ulcerated area with its adjacent mesentery is a simpler procedure than lysis of the gastrojejunostomy and wedge resection of the ulcer. Moreover, intestinal continuity is easily restored by a closed type of anastomosis, thereby minimizing the soiling which accompanies the taking down of the gastroenterostomy and plastic procedure on the jejunum. After the triangular area of mesentery is prepared for removal, two Furness clamps, the McClure modification with the detachable handle is particularly useful in this location, are applied to the jejunum proximal to the anastomosis and distal to the ulcer. Kocher clamps are put on distal to the upper Furness clamp and proximal to the lower one (Fig. 3), and the bowel is sectioned with the cautery between the Kocher and Furness clamps. The stomach and short jejunal loops are

maneuver can be carried out only if the proximal loop is of sufficient length to permit application of the clamp. In one of our patients the afferent loop was so short that an open end-to-end anastomosis had to be performed. Mobilization of the ligament of Treitz is helpful when difficulty is experienced. Closure of the opening in the mesentery completes this step. If the previous operation has been a gastroenterostomy, subtotal gastric resection is then performed. The duodenum is sectioned at the pylorus and closed. After ligating the main blood vessels, Ochsner-Kocher clamps are applied in pairs to both the greater and lesser curvatures and the lower three-fourths of the stomach is removed. If the clamps are put on obliquely at an angle of 135 degrees (Fig. 5) instead of transversely, closure of the portion of stomach held by the clamp applied from the lesser curvature side will allow the stomach in the grasp of the remaining clamp to be drawn out in the form of a tube. (Fig. 6.) Isoperistaltic retrocolic terminolateral gastrojejunostomy is then effected with two rows of sutures, an inner of continuous chronic catgut, and an outer of interrupted fine silk su-

tures. The anastomosis of course is distal to the restored jejunum. (Fig. 7.)

In those instances in which the jejunal ulcer has followed a partial gastrectomy

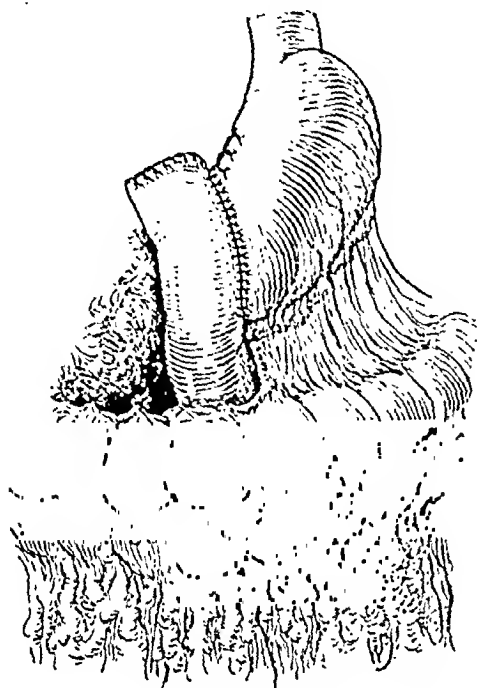


FIG. 9. Gastroduodenostomy, Von Haberer-Finney technic; alternative method of restoration of continuity.

there is an absolute indication for removal of more gastric tissue. In this group of cases it is prudent as Lahey points out to make an antecolic type of anastomosis (Fig. 8) in the event surgical intervention might again become necessary.

As an alternative method, restoration of continuity may be accomplished by gastroduodenostomy following the Von Haberer Finney technic. (Fig. 9.) Adequate mobilization of the duodenum and fashioning the stomach remnant in the form of tube as described in the foregoing will permit the resection of almost as much gastric tissue as is removed in the usual operation of subtotal gastrectomy. On theoretic grounds gastroduodenostomy should be preferable to gastrojejunostomy especially since the jejunal mucosa of the patients has already exhibited increased susceptibility to the direct action of gastric contents.

This operation obviously has a limited application since it can be employed only in those cases of jejunal ulcer which follow gastro-enterostomy, for technical difficulties will preclude its use if subtotal gastrectomy has already been performed. Our own experience with gastroduodenostomy after excision of jejunal ulcer is limited to one case, but the necessity for performing a second operation for jejunal ulcer upon two patients during the past year has caused us to reconsider the advisability of adopting this method of gastro-intestinal anastomosis. Certainly it is a procedure that is preferable to resection of the ulcer and lysis of the gastrojejunostomy without gastrectomy, though the recent work of Dragstedt⁹ indicates that in the future vagotomy plus restoration may be the operation of choice.

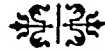
SUMMARY AND CONCLUSIONS

1. Jejunal ulcer is a more descriptive term than anastomotic or stomal ulcer, for ulceration occurring after gastrojejunal anastomosis.
2. All jejunal ulcers appear opposite the stoma or in the efferent loop.
3. Hemorrhage and perforation are common.
4. Diagnosis is based largely on clinical evidence of recurrence of ulcer symptoms after operation and confirmatory x-ray evidence is often wanting.
5. Resection of the involved segment of a jejunum with end-to-end anastomosis is a simpler and safer procedure than excision and plastic closure.
6. Subtotal gastric resection is clearly indicated. A method which limits peritoneal soiling is described.
7. Recurrence of jejunal ulcer in patients with ulcer diatheses occurs even after adequate gastric resection.

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PYLORIC occlusion with secondary vomiting and dilatation of the stomach occurs either from cicatricial contraction or from the swelling and edema associated with an ulcer. Rare complications are the occlusion of the bile duct with stone formation and jaundice; and pancreatitis from invasion of the pancreas or obstruction of a pancreatic duct.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

CORRECTION OF THE CONGENITAL PROTRUDING EAR*

A NEW SURGICAL CONCEPT

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MUCH has been written concerning the restoration of protruding ears in the past few years, particularly during the maze of progress of plastic surgery. Up to the present time, the most logical and practical correction has been advanced by Young,¹² of Rochester, New York.

Young's procedure may be adopted to most cases requiring correction particularly when the correction involves bringing the outer rim of the protruding ear closer to the head. While this procedure goes extensively further relative to the anatomical restoration of the ear, I believe that it does not go far enough and that correction, involving the conchoidal flare and protrusion of the lobule cannot be obviated with Young's procedure alone. It requires still further anatomical resection.

It has been my custom to pursue the following procedure for such cases: As near as possible first the abnormal ear is grasped with both hands and flexed toward the head so as to visualize or bring into effect the position that an antihelix would occupy. At the same time the delineation of the crura of the triangular fossae is emphasized. With the use of six hypodermic needles, $\frac{5}{8}$ inch in length, one needle pierces the antihelix at the junction of the crura of the triangular fossa. A second and third needle pierce the outer third of each crus. Distally, a fourth needle pierces the continuation of the antihelix just medial to the antitragus. The fifth needle pierces the middle of the cavum conchae just on a level with the external auditory meatus. A sixth needle pierces the base of the intertragic notch. The most important part of this procedure

is the proper placing of the needles at the junction of the forked arms. The exits of these needles on the posterior surface are connected with marking dye. The dye markings thus drawn present a distal Y bar and a superior Y bar joined at the base of their stems. The needles at this point may be withdrawn. This marking procedure will delineate the position of the incisions to be made on the posterior surface of the auricle.

The operative procedure is most satisfactorily carried out under procain nerve block with supplemental procain infiltration anesthesia. This procedure is adopted for the young as well as for the old. It is advisable to operate on children as early as eight years of age under local anesthesia. All nervousness and fear can be allayed with proper sedation and psychological management. The amount of anesthesia used can be reduced as little as 5 to 8 cc., provided the bore of the needle is sufficiently small enough, 27 or 30 gauge, and the distribution of the procain is carried out in the proper manner.

As soon as the incision is carried out according to the marking dye, one usually finds that the incisions are deep enough to make the same delineations on the perichondrium posteriorly. The perichondrium on the posterior portion of the auricular cartilage can be sacrificed and need not necessarily be elevated from the posterior surface of the auricular cartilage. To do so may fragment the cartilage and may cause unnecessary delay as well as loss of artistic excision.

Through the visible incised perichondrial markings the cartilage is further incised and from this point on the triangular flaps

*Presented at the Manhattan Eye, Ear and Throat Hospital, New York City, with case demonstration and motion picture, March 26, 1946.

of cartilage thus outlined are elevated from the pre-auricular perichondrial attachment. This is the most important part of the procedure. At this stage three triangular flaps exist, a superior, inferior and a conchoidal triangular flap with a very broad base. The superior triangular flap represents the cartilage outlining the triangular fossa. The inferior one represents the cartilage at the floor of the cavum conchae and the larger one represents the portion of the auricular cartilage which is continuous with the external canal proper. At this time the rim of the cartilage outlining the antihelix is elevated subperichondrially from the anterior perichondrial sheath. The next step in the procedure is to remove an arrowhead pattern segment of cartilage from each triangular cartilaginous flap. This arrowhead pattern segment is virtually a v-shaped section of cartilage, broadest at the apex and tapering to a point in each of its arms. This procedure is carried out for each triangular cartilaginous flap. The sections removed are resected according to judgment, viz., size of cartilage presented, the size of the original ear, and the correction desired. However, it is always advisable to err on the side of removing a segment slightly smaller than to remove too large a segment.

The arrowhead pattern is resected as follows: At a point approximately 2 to 3 mm. from the inferior apex point of the triangular cartilage, delineating the triangular fossa, an incision is made paralleling the upper arm of the triangular fossa and tapering gradually toward it until it meets the first incision at a distance just below the scapha. Starting again at the apex, a similar incision is carried along the inferior arm toward the scapha. The result of this procedure is to remove an arrowhead-shaped section of cartilage surrounding the triangular fossa. This permits marked freedom of flexibility of the balance of the auricular cartilage about the triangular fossa area. The triangular fossa section of the cartilage becomes more prominent as the skin and perichondrium

are draped over the new formed ridges. Similar pattern resections are performed on each of the other two triangular cartilage flaps.

If, after the three sections have been removed the apparent reduction in the auricle to the side of the head is insufficient, the procedure is duplicated by resecting a second section of cartilage from the particular triangular flap which may cause the residual protrusion. In any case the pattern is the same. The procedure is the same. Herein lies the value of this particular surgical procedure for should multiple excisions be necessary the remaining cartilage flaps will fall into a normal anatomical relationship.

It is to be noted here that the section removed from the conchoidal cartilage should have a somewhat curved surface to fit in well with the antihelicine curve and the incision originally made. However, this section, on removal, still retains its arrowhead-shaped appearance.

Subsequent to the removal of the first section of each triangular cartilaginous flap or to the removal of the second section of each triangular flap, the helix and soft parts of the ear are allowed to fall back over the resected cartilaginous surface. A study of the anterior auricular surface is made for anatomical configuration. If the contour is normal, it is proper to proceed with closure of the posterior wound. However, in extremely large ears, as in the case here presented, there will be additional buckling, bowing or recoiling of the cartilage in unexpected places particularly about the bordering rim. This buckling can be obviated not by cutting through the helix rim, as many surgeons have outlined, but by preservation of the rim. In its stead I remove a small triangular wedge whose base abuts the extreme end of each incision outlining the arrowhead pattern. These segments usually vary from 1 to 2 mm. at their base and 2 to 4 mm. at their sides.

This triangular section must be gauged according to the operator and judged according to the size of the cartilage and

ear one is dealing with. It will be found that when this additional step is utilized, the ear will fall back toward the head without tension, mobilization of the soft tissue will be completely obtained and resection of the cartilage, will be properly and anatomically done. One could interpret this procedure as a preservation of anatomical contours accomplished by means of anatomical resections.

It is to be noted that from the original incisions in the skin and subcutaneous tissues similar triangular sections of soft tissue are presented overlying the resected cartilages. The pattern resection applied to the cartilage flaps is now applied to the soft tissue flaps. These latter resections result in a reduction of soft tissue of the postauricular skin and subcutaneous tissue. This procedure facilitates the accomplishment of anatomical contours by obviating redundant soft tissue which would unnecessarily interpose between the cartilaginous incisions.

The procedure subsequent to the excision of the postauricular soft tissue is to suture the wound edges of soft tissue and perichondrium with interrupted sutures of c silk mattress and single sutures as desired. When the procedure is completed posteriorly the closed incision resembles the original incision except that it is shorter in all its directions due to the resection. If at this stage, there is an anterior or vertical protrusion of the lobule of the ear to the head, the procedure is to resect a section of skin and subcutaneous tissue in the posterior surface, triangular in shape, the base coinciding with the base of the inferior triangle, the apex directed inferiorly. When the included soft tissue is removed, the wound edges are approximated in a vertical direction. This procedure then will be a complete correction for protrusion of the helix, the conchoidal cartilage and the lobule, any one of which, existing alone, may be corrected by adopting the above procedure to the particular abnormality; should all exist at the same time, all the above steps must be accomplished at one sitting.

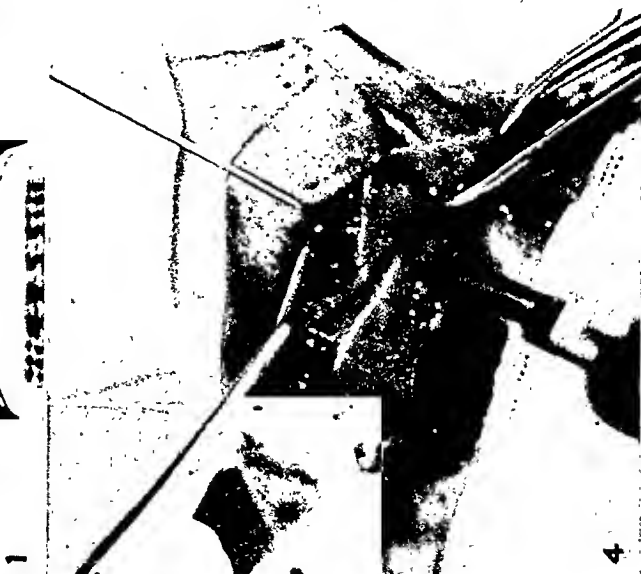
As a final step in the procedure and to preserve anatomical contour to prevent hematoma formation and cauliflower ears and to facilitate union as well as to preserve the plastic correction obtained at operation, it is advisable to utilize the Kitlowski procedure of using mattress sutures of silk or No. 35 steel alloy wire or tantalum wire .0003 over vaselized gauze. These sutures are carried through the skin and cartilage of the scapha, thence through the cartilage and skin of the concha, thence from the skin and cartilage of the concha through the cartilage and skin of the scapha. Vaseline gauze is interposed between the loops and the sutures are tied. This permits an abutment of the conchoidal and scapha cartilages so as to preserve the new antihelix. In this particular procedure, usually such sutures are necessary but particular note must be made in the application of the superior suture which traverses the skin and subcutaneous tissues and cartilage of the scapha and concha cartilage and skin and then on return traverses the skin and cartilage of the concha, then through the cartilage and skin of the triangular fossa on the medial limbus coming out over the triangular fossa and then through the skin and cartilage of the posterior limbus of the triangular fossa through the cartilage of the scapha and thence through the skin. A small plug of vaseline gauze is inserted under the loop in the triangular fossa to preserve contour in the scapha and triangular fossa. These sutures are allowed to remain in place for two weeks before any dressing is done. At the end of that time, the procedure is to remove the mattress sutures and vaseline gauze as well as postauricular sutures. A mastoid dressing is reapplied for a period of another week at the end of which time the patient is allowed to go about without a dressing.

It is to be noted from the pictures presented that the reconstructed ears present the anatomical contours of concha, antihelix and helix and present no evidence of a hinged back ear which is typical in cases in which the helix has been split



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FIG. 1. Preoperative view to show wide auriclecephalic angle.
 FIG. 2. The marking dye demonstrates the direction of external incisions on posterior surface of the ear.
 FIG. 3. Demonstrating the arrowhead cartilaginous resection in the superior triangular cartilaginous flap.
 FIG. 4. Demonstrating arrowhead patterns from the superior, middle and inferior triangular cartilaginous flaps.
 FIG. 5. Postoperative view to show improved condition.



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to accomplish the result. The above procedure, does not present the hideous clam shell conchoidal flare and anterior concave flaring of superior and inferior poles of the auricle characteristic of reconstruction procedures in which equal segments of skin and subcutaneous tissue are removed from the postauricular and mastoid surface with coaptation of the wound edges.

In most cases of protruding ears, the flare deformity extends inferiorly as well as superiorly and the lobule of the ear is protruding and there is a marked protrusion of the conchoidal portion inferiorly from the antitragohelicine fissure to the isthmus of the auricular cartilage.

When the correction has been made according to all other procedures, the primary consequence is flexion of the helix toward the head. In the lower two-thirds of the pinna proper thus far no attempt has been made to correct the shell-like flare of a marked conchoidal protrusion inferiorly. Likewise, the previous corrections for protruding ears do not permit the formation of a well developed triangular fossa delineated by upper and lower arm extensions.

SUMMARY

1. No where in the literature can one find a plan of reconstruction of the abnormally protruding ear which can be adopted universally.

2. The procedure here outlined is simple. It can be followed step by step and at no time leaves the surgeon in a quandary as to the site of cartilaginous excision.

3. This procedure can and should, if possible, be carried out under local anesthesia. While it is simple, it requires thoroughness and patience.

4. This procedure should be easy of accomplishment by any competent plastic surgeon.

5. This procedure is anatomical and when properly done results in the maximum anatomical correction.

6. General anesthesia may be admin-

istered but is not desirable owing to the difficulty presented with anesthetist and assistants about the head. The surgeon should sit during the operation.

7. This procedure, owing to the complete mobilization of cartilage, soft tissue and perichondrium and the redraping of soft tissue over anatomical contours is not followed by the complaint of pain on the part of the patient.

8. This procedure permits not only the correction of protruding ears but a reduction in the size of abnormally large ears.

9. This procedure can be adapted to minimal or maximum corrections.

10. This procedure does not interfere with the soft tissues over the mastoid process, and, therefore, would not be a source of disturbance to the mastoid surgeon.

11. The author has followed this procedure during three years, in many cases. The illustrations demonstrate its simplicity.

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COMFORT IN CASES OF ANORECTAL SURGERY

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IT is the purpose of this paper to describe certain observations and procedures relative to the comfort of the patient, whenever anorectal surgery is required.

An individual, affected with a painful anorectal disease is in need of sympathy. Immediately, at the occasion of his first visit he should be given the assurance that the cause of his distress can be determined painlessly and with a minimum of discomfort. Thrombotic hemorrhoids, for instance, are easily seen. A fissure in ano can be made visible upon retracting the buttocks while the patient bears down. An abscess is localized by superficial or deep palpation alongside the external sphincter. Only occasionally will it be found necessary to insert the finger in order to ascertain the presence of a submucous abscess or one situated above the levator ani. When pain in the anorectal line is due to malignancy or fecal impaction, digital examination becomes necessary. In cases of painful lesions proctoscopy may be deferred except in those instances in which malignancy is suspected and the diagnosis not definite. Further examination can be carried out under topical anesthesia, using a 4 per cent solution of metycaine, or at time of surgery.

The patient should be protected from fear and from pain during his preoperative stay at the hospital. The night preceding operation nembutal is given to induce sleep. Whenever pain in the anal outlet is present, 2 cc. demerol is administered hypodermically, one hour before the cleaning enemas. Nembutal, morphine or scopolamine—the dose adjusted to age and weight of the patient—is given as a standard procedure to induce drowsiness or sleep prior to surgery.

Caudal, transsacral or local anesthesia is used instead of spinal anesthesia for anorectal surgery, in order to prevent the incidence of postoperative headaches. At the conclusion of the operation, oil anesthesia—preferably zylcaine—is injected beneath the cut surfaces, except in acutely infected areas. In carrying out this procedure, care is taken to avoid the sphincters; thus in case of sensitivity to the oil anesthetic the ensuing induration will not extend into the anal canal and form a fistula. A dose of 7 to 10 cc. of oil will induce only partial prolonged anesthesia. However, it is inadvisable to increase this amount, as larger doses of oil anesthesia occasionally cause incontinence. Such a loss of control will first become evident when on the third postoperative day an enema is given, and may occasionally persist over a period of two months. Every effort should be made to avoid the occurrence of incontinence, as such an experience may produce mental shock in sensitive patients. Partial prolonged anesthesia, which does not cause incontinence, allows for a certain amount of pain which is controlled by opiates, demerol and aminopyrine.

Postoperative comfort for the patient is dependent upon adherence to detailed instructions. This is best accomplished by printed orders. It should be part of the routine procedure to individualize and sign such orders at the time of completion and signing of the patient's history and physical examination records. The standard orders which have been compiled for this purpose are simple, easily executed and make it incumbent upon the nurse to keep the patient comfortable. These orders are printed on four separate pages of hospital chart size; the last page contains

home directions and is intended to be given to the patient upon discharge.

HOSPITAL TREATMENT (Page One) RECORD

Name..... Adm. No.....

Patient Entering Hospital for Anorectal Surgery

Anesthesia will be caudal or local.

Light supper.

Prepare for surgery by

Tap water enemas until returns clear.

No local preparation.

Sodium pentobarbital gr. 1.5 at bedtime.

Repeat if necessary for sleep. For painful anal outlet precede enemas by demerol 2 cc. Use small colon tube or catheter.

Day of Operation

Before Surgery:

No breakfast for surgery before 11 A.M. Otherwise light breakfast.

Sodium pentobarbital grs. 4.5, one-and-a-half hour before surgery.

Morphine sulfate gr. $\frac{1}{4}$, scopolamine gr. $\frac{1}{150}$, one-half hour before surgery.

After Surgery:

Morphine sulfate gr. $\frac{1}{4}$ before anesthesia is completely worn off.

Repeat every one to four hours as needed to keep patient comfortable.

Catheterize in 8 hours or before if distressed.

Instill 30 cc. of $\frac{1}{2}$ per cent mercurochrome solution. Then catheterize every 8 hours p.r.n.

May sit up on side of bed to void. Non residue diet. Patient should have 2 glasses of water and 2 glasses of fruit juices if too sleepy to eat. For emesis, substitute dilaudid gr. $\frac{1}{16}$ for morphine.

Adjust and replace soiled dressings at bedtime.

Signature:

HOSPITAL TREATMENT (Page Two) RECORD

Name..... Adm. No.....

First Postoperative Day

Demerol 50 mg. 2 tabs. by mouth every six hours. Use demerol 2 cc. subcutaneous if nauseated.

Hot compresses or infra red lamp t.i.d.

Mercurochrome 2 per cent and antipyrexol to wounds. Leave at bedside with cotton applicator.

Non residue diet.

Petrogalar plain, 1 tablespoon after meals.

Ambulatory.

Sodium pentobarbital gr. 1.5 p.r.n. for sleep.

Aminopyrine gr. 5, tabs. 6 at bedside. Directions: 2 tabs. every one hour if necessary for comfort.

Second Postoperative Day

Demerol 50 mg. 2 tabs by mouth every six hours.

Hot compresses or infra red lamp t.i.d.

Mercurochrome 2 per cent and antipyrexol to wounds.

Regular diet. Petrogalar plain, one teaspoon after meals.

Ambulatory.

Sodium pentobarbital gr. 1.5 p.r.n. for sleep.

Aminopyrine gr. 5, tabs. 6 at bedside. Directions: 2 tabs. every one hour if necessary for comfort.

Signature:

HOSPITAL TREATMENT (Page Three) RECORD

Name..... Adm. No.....

Third Postoperative Day

Demerol 2 cc. Remove rubber wick. Follow in one hour with enema, two teaspoons full of hydrogen peroxide to one quart of tap water through a small colon tube or large catheter.

Ambulatory.

Regular diet.

Sitz bath or heat to anal region after enema.

Mercurochrome 2 per cent and antipyrexol to wounds.

Demerol 50 mg. 2 tabs. every six hours. Space 4 hours after demerol hypo. Petrogalar plain, one teaspoon full after meals.

Sodium pentobarbital gr. 1.5 p.r.n. for sleep.

Aminopyrine gr. 5, tabs. 6 at bedside. Directions: 2 tabs. every one hour as needed for comfort.

Fourth Postoperative Day and Daily

Ambulatory.

Regular diet.

Petrogalar plain, one teaspoon full after meals.

Hot sitz bath or other heat p.r.n.

Demerol one tablet every 6 hours.

Mercurochrome 2 per cent and antipyrexol to wounds after bowel movement.

Tap water enema one pint, p.r.n.

Sodium pentobarbital gr. 1.5 p.r.n. for sleep.

Aminopyrine gr. 5, tabs. 6 at bedside. Direc-

tions: 2 tabs. every one hour as needed for comfort.

May go home fifth postoperative day or any day following.

Signature:

TO TAKE HOME FROM THE HOSPITAL (Page Four)

Antipyrexol. 2 per cent mercurochrome. Cotton. Applicators (can make own applicators at home with tooth-pick and cotton).

Petrogalar plain. Aminopyrine gr. 5, 20 tabs.

On arising take one-half teaspoon full of table salt in glass of cold water, followed by another glass of water.

Two tabs. Aminopyrine, one-half to one hour before breakfast.

Bathroom after breakfast; if no bowel movement, may take teacup of tap water enema. Aminopyrine 2 tabs. one hour before bowel movement will prevent pain. May use glycerine suppository instead of enema.

After bowel movement take hot sitzbath or hot compresses.

Paint wounds with 2 per cent mercurochrome and apply ointment on a swab.

Take one tablet aminopyrine every 4 hours or oftener as needed to keep comfortable.

Apply hot compresses to anal region as needed for comfort.

Petrogalar plain, one teaspoon full after meals to keep movements soft; gradually lessen dose to stop in 3 weeks from surgery.

Report to office once weekly or oftener.

Signature:

An analysis of 200 hospitalized anorectal surgical cases from the year 1945, in which these routine orders were followed, reveals possible hazards and points the way to further improvement.

Approximately 90 per cent of the patients had a comfortable postoperative course, while the remaining 10 per cent suffered a certain amount of pain. The chief cause of discomfort in these cases was due to the inability to give the drugs used to control pain, because of drug idiosyncrasy of the patient. Rarely did the

nurse show insufficient judgment as to the time of giving opiates. Occasionally a patient will be supersensitive to pain.

Of the 200 cases, 133 received caudal or transsacral, while fifty-six received local anesthesia. Spinal anesthesia was avoided, as previous experience with that method in clinic patients led to headaches in a considerable number of cases. Jennings and Karabin³ report an incidence of cephalalgia in 30.6 per cent, mostly after anorectal operations.

A series of cases receiving caudal or local anesthesia will rarely be without complications. Surgical anesthesia of the buttocks and the perineum developed within ten minutes after injection of 6 cc. of a 2 per cent intracain solution in one patient to whom a caudal anesthetic was being administered. Aspiration had not obtained spinal fluid. It was assumed that the needle must have entered the sub-arachnoid space in order to have produced anesthesia with such a small volume of the anesthetic agent. Two patients suffered convulsions, and one twitching while the caudal anesthetic was administered, and these symptoms were considered to be intravenous reactions to the anesthetic. Severe backache occurred in two patients after the anesthetic solution had been injected outside the sacral canal. Complications of caudal anesthesia and their management have been described by Gready.¹ One patient developed a deep anal and perianal infection following local anesthesia. Contamination can be prevented by placing an aspiration needle into the anesthetic solution, refilling the syringe through the needle rather than by dipping the tip of the syringe into the solution.

The patients were allowed out of bed as soon as awake from the effects of pre-medication. The postoperative course was disturbed most frequently by nausea and vomiting. In 21 per cent of cases in which this occurred during the first twenty-four hours, it was considered due chiefly to morphine. Demerol caused nausea and

vomiting in 8 per cent of cases, 3.5 per cent of which were after hypodermic administration only. It should be mentioned that the vomiting caused by demerol is not as intense or as prolonged as that resulting from morphine. The substitution of demerol for morphine in premedication seems indicated, as reported by Rovenstine and Batterman.⁴

Catheterization was necessary in 45 per cent of the cases, 5.5 per cent of which required a second catheterization. At each catheterization 30 cc. of an 0.5 per cent aqueous solution of mercurochrome was instilled in order to promote bladder contraction, as reported by Helfert and Granet.² It remains an open question whether it is preferable to catheterize 100 per cent in surgery, instilling this solution immediately to exclude the necessity for further catheterization; or whether it might be better to wait and instill the solution in the 45 per cent of cases which require catheterization subsequent to surgery.

After leaving the hospital, the 200 patients presented in this series were treated in the office at weekly intervals, until healing occurred and function became normal.

SUMMARY

The comfort of the patient suffering from an anorectal disease can be safeguarded through a sequence of carefully chosen measures:

1. Examination should be made without causing distress. Painful lesions are localized from the anorectal line downward, and can be diagnosed by vision and gentle palpation.

2. Premedication protects the patient from the pain of enemas and the fear of surgery.

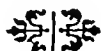
3. By substituting caudal, transsacral or local anesthesia for spinal anesthesia, headaches can be prevented. Oil anesthesia, chiefly zylcaine, in 7 to 10 cc. dosage underlaid beneath the cut surface produces partial prolonged anesthesia. Complete prolonged anesthesia is not desired as it may lead to transient incontinence.

4. Postoperative comfort is best assured by individualized standard routine orders, signed together with the history and physical examination records. Text of routine orders is presented.

Analysis of 200 anorectal surgical cases, as to complications and results, points the way to caution and improved procedure.

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SPONDYLOLYSIS AND ITS RELATION TO SPONDYLOLISTHESIS*

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AND

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SPONDYLOLYSIS literally means dissolution of all or part of a vertebra.

Through common usage it has become synonymous with defects of the neural arch. It has been shown that the most important arch defects are those of the isthmus region,^{1,2} and therefore it is to these defects that the term spondylolysis is applied in this paper.

Spondylolisthesis is a well recognized clinical entity.³ The frequent coexistence of spondylolisthesis in spondylolysis has shown the need for an evaluation of this relationship from a roentgenological and clinical standpoint.

The diagnosis of spondylolysis with or without spondylolisthesis is established by adequate x-ray studies. An understanding of the gross anatomy of the lower lumbar region is required for proper interpretation of the roentgenograms. Routinely these include an anteroposterior projection (Fig. 1), a lateral projection (Fig. 2) and frequently a spot lateral projection of the lumbosacral joint. The anatomical structures revealed are indicated by corresponding diagrams.

The anteroposterior view (Fig. 1) indicates the number of lumbar vertebrae, and outlines the bodies and transverse processes, the depth of the upper lumbar intervertebral spaces and the alignment of the vertebral column. Due to angulation produced by the lumbosacral curvature and other physical factors, the presacral vertebra is poorly delineated and there is imperfect definition of the articular processes, the apophyseal joints and the interarticular or isthmus segments.

From the diagram (Fig. 4) it can be seen that the lateral view reliably presents the

outline of each vertebral body, the depth of the intervertebral and lumbosacral spaces, the anteroposterior alignment of the vertebrae and the configuration of the spinous processes. The usefulness of the lateral view is limited by two features: (1) It superimposes the images of each half of the neural arch so that the lamina, articular processes, apophyseal joint and isthmus of the right side cannot be distinguished from the left, and (2) the apophyseal joint which lies at an angle ranging from 35 to 50 degrees anterior to the sagittal plane is not visualized nor are its components.

Because of these features, specific roentgen information about each half of the neural arch, particularly the pars interarticularis, can only be obtained by rotating the contralateral side anteriorly away from the cassette with the subject in the supine position. Thus the plane of the apophyseal joint in question is made to coincide with the tube-target beam and the corresponding articular processes, pars interarticularis and lamina for that half or side of the neural arch are clearly revealed. This is the essence of the oblique projection (Fig. 5) and the graphic representation (Fig. 6) confirms its primary importance in disclosing lesions of the isthmus and neighboring structures.

Spondylolysis and spondylolisthesis, when seen roentgenographically, affect the last or presacral lumbar vertebra almost exclusively. The presence and degree of displacement are determined from the lateral views using the criteria of Ferguson⁴ although a recently described method is also of merit.⁵ The lateral view reveals isthmus defects but does not dis-

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tinguish between unilateral or bilateral defects, nor does it indicate which side is involved. This point is illustrated in Figure 7.

the neural arch which connects the inferior articular process with the pedicle and the lamina. It is smooth in outline, usually bilateral and varies in width with the de-



FIG. 1. Normal anteroposterior film.



FIG. 2. Normal lateral film.

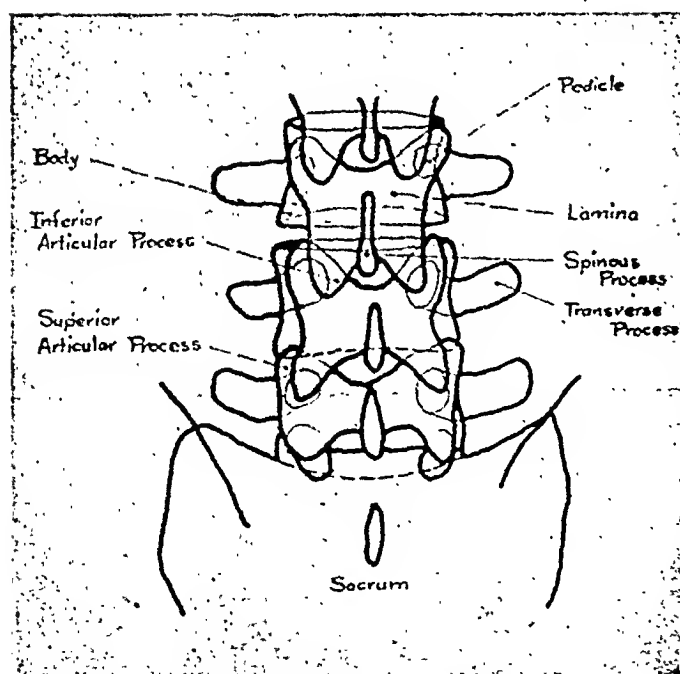


FIG. 3. Diagram of anteroposterior film.

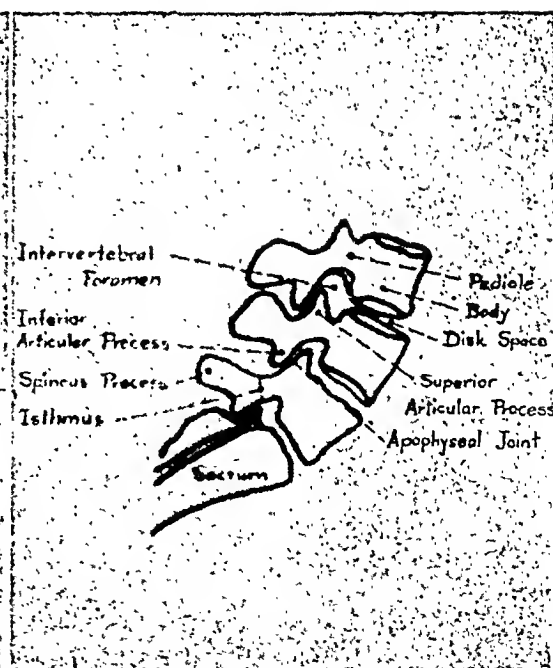


FIG. 4. Diagram of lateral film.

The lateral projection also indicates alterations in the disks, the intervertebral spaces, the intervertebral foramina and the vertebral bodies.

The defect of spondylolysis as seen in the oblique view is a gap in that segment of

gree of spondylolisthesis. Its presence may be suspected by a posterior indentation of Morton's S-shaped line⁶ indicating recession of that apophysis continuous with the defective (shortened) lamina. Figure 8 illustrates the defect of spondylolysis.

Frequently, there are associated anomalies and abnormalities of the neural arch such as spina bifida occulta, or varying

sory ossicles of the inferior articular processes. The former condition is seen as an irregular defect with sclerotic mar-



FIG. 5. Normal oblique (left) film.

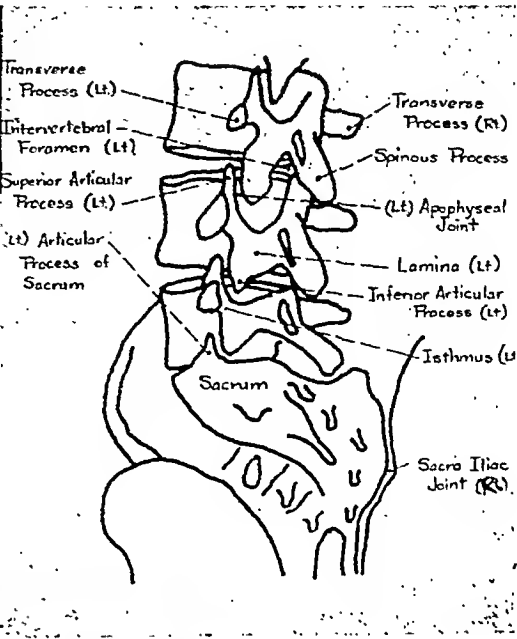


FIG. 6. Diagram of oblique film.



FIG. 7. Lateral film showing isthmus defect.

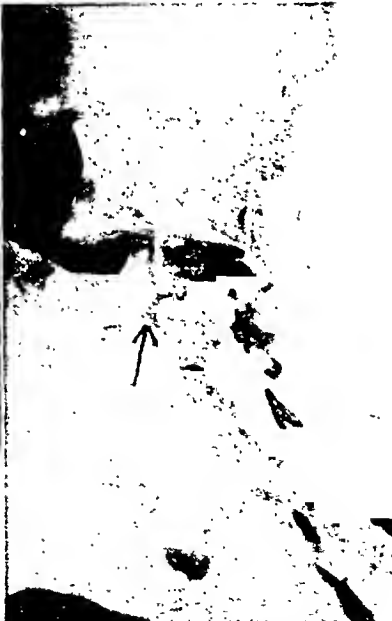


FIG. 8. Oblique film showing isthmus defect.

degrees of maldevelopment of the lamina and articular processes.

The defect must be distinguished from fracture of the isthmus and from acces-

sory ossicles of the inferior articular processes. The former condition is seen as an irregular defect with sclerotic mar-

gins, usually producing callus and almost always unilateral. The latter condition is bilateral and seen as a small bone having a smooth outline and a well defined cortex,

located beneath the tip of each inferior articular process.

While a unilateral or bilateral defect may occur with or without slipping of a vertebra, in no instance in this series did spondylolisthesis occur without a defect of the isthmus whether unilateral or bilateral. The presence of spondylolisthesis is therefore believed to be *prima facie* evidence of spondylolysis.

It must be borne in mind that many conditions may produce symptoms similar to those of spondylolysis and spondylolisthesis with roentgen findings which are quite different. The more important ones of this nature are: subluxation of the apophyses, arthritis of the apophyses, and various forms of disk disorders. Furthermore, similar clinical findings are produced by a host of lesions which have no demonstrable x-ray changes. As a last caution one must avoid "overreading" films and subject all x-ray findings to a rigid scrutiny lest pathologic significance be ascribed to a harmless variation. This admonition is particularly apt in the lumbosacral region where the normal appearance is of such wide variability.

As has been stated it is believed that spondylolisthesis cannot occur without a defect in the neural arch of the displaced vertebra. The location, nature and mechanism of production of this defect are controversial, but the most widely accepted explanation is that the isthmus is the site of a hidden congenital or developmental defect.^{1,2,7,8} This when subjected to trauma becomes manifest and may or may not be followed by spondylolisthesis. In this study of sixty cases of spondylolysis, conducted over a nine-month period, the onset of symptoms was preceded in all by some form of trauma. Commonly, the injury was apparently trivial but in the presence of the hidden defect constituted the "straw that broke the camel's back."

Spondylolysis with or without spondylolisthesis is more prevalent than has been heretofore realized. Thus, thirty-nine cases

were found in 250 examinations done specifically for low back complaints, while the remaining twenty-one cases were incidental findings in 1,000 routine lumbosacral roentgen studies.

TABLE I

		Cases of Spondylolysis
Routine low back exams.....	1,000	21
Specific low back exams.....	250	39
Totals.....	1,250	60

The overall incidence, sixty cases of spondylolysis in 1,250 examinations, compares with the results of other investigators. The majority of cases of spondylolysis occurred in younger individuals, approximately three-fourths of whom were recently discharged service men in the third or fourth decade. Incidence relative to sex is lacking, males constituting 98 per cent of the cases.

A typical history included "back trouble" existing for some time before induction. This complaint had developed following severe trauma such as a fall or a severe wrenching strain while engaged in various athletic pursuits. Occasionally, the symptoms were mild and of gradual onset. The precipitation of acute incapacitating symptoms was almost invariably ascribed to the rigors of military life such as: calisthenics, marching and jumping with full pack, obstacle courses and infiltration tactics.

TABLE II

No displacement.....	5
First degree displacement.....	26
Second degree displacement.....	7
Third degree displacement.....	1
Fourth degree displacement.....	0
Totals.....	39

The objective findings were meager: limitation of motion, external lumbar deformity, and local tenderness being most common. Extension of the spine was

frequently limited and flexion hesitantly performed. Visible external deformity required severe displacement which was uncommon.

Tenderness over the spinous process of the affected presacral vertebra was the most constant finding. The paucity of physical findings cast some doubt on the significance of the symptoms, in some instances leading to the erroneous army diagnosis of psychoneurosis with subsequent discharge, and in other instances leading to the suspicion of malingering. Rarer still were neurological findings. Lasegue's test was occasionally mildly positive, but was only once associated with additional evidence of sciatic nerve irritation. Findings indicative of disk herniation or nerve root compression were lacking, suggesting another mechanism for the production of the pain in spondylolisthesis.

A breakdown of 100 consecutive cases of low back pain revealed that only five carried an army discharge diagnosis of herniated intervertebral disk. In none of these could the diagnosis be confirmed, while only one of the remaining ninety-five cases was given a presumptive diagnosis of disk herniation.

TABLE III

Major Army Discharge Diagnosis	No.	Cases of Spondylolysis
Low back injury (incl. lumbosacral or sacro-iliac sprain)...	25	2
Arthritis, lumbar spine.....	25	1
Low back pain (incl. lumbago, etc.).....	16	2
Spondylolisthesis.....	10	10
Sacro-iliac disease.....	8	0
Anomalies of lower spine.....	5	1
Sciatica.....	5	0
Herniated intervertebral disk...	5	1
Psychoneurosis.....	1	1
Totals.....	100	18

In addition to the ten cases of spondylolisthesis wherein the army diagnosis was confirmed, eight additional cases were

discovered, five having been previously given a primary or secondary diagnosis of psychoneurosis.

A review of the x-rays in these cases of spondylolisthesis emphasized several facts and posed a few problems. The single diagnostic measure of primary importance is the roentgenogram, particularly the oblique projection. The 35 degree cephalad cone-tilt⁹ used in a few cases failed to supply definitive evidence.

Since a loose segment of neural arch is essential for the production of vertebral displacement,¹⁰ unilateral isthmus defects cannot mechanically produce spondylolisthesis unless associated with another laminal defect. A few cases of spondylolisthesis, however, were seen in which only a single isthmus defect was demonstrable, but in none of these was the contralateral isthmus entirely normal roentgenographically. In these cases it is believed that oblique projections taken in varying degrees of obliquity would disclose a defect of the contralateral isthmus.

A confirmatory diagnostic finding is evident at the operating table. In eight cases of spondylolysis with spondylolisthesis, direct manipulation of the exposed spinous process of the affected vertebra demonstrated abnormal mobility. Two of these cases presented only unilateral defects on the roentgenograms.

The treatment of spondylolysis depends on the nature of the defect and the absence or presence of vertebral displacement. These three factors served to classify the cases into three groups: (1) Unequivocal unilateral isthmus defects. These cases require no treatment. (2) Bilateral isthmus defects without vertebral displacement. This group includes those cases with unilateral isthmus defects associated with an additional laminal defect. A prosthetic brace, preferably of the Taylor variety, is recommended for these patients, and they are cautioned to avoid strenuous physical exertion. (3) Bilateral defects with vertebral displacement. These patients are offered the choice of a brace or

surgery unless advanced age or a serious coexisting disease contraindicate surgery.

Only eight patients have been subjected to surgery making any conclusions or detailed analyses premature. The clothespin type¹¹ of spine fusion using an autogenous tibial graft is considered the procedure of choice. All six patients who underwent the fusion operation have thus far not experienced any return of symptoms.

SUMMARY

An evaluation of the relationship between spondylolysis and spondylolisthesis has been made from a roentgenological and clinical standpoint. The clinical material consisted of sixty cases observed in 1,250 examinations.

CONCLUSIONS

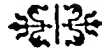
1. Spondylolisthesis predicates spondylolysis.
2. The incidence of spondylolysis is greater than has been realized, and it should be sought for in all cases of low back pain.
3. Roentgenograms, particularly the oblique projection, are diagnostic.
4. Trauma may frequently render an

asymptomatic spondylolysis symptomatic.

5. The treatment is largely conservative, but in selected cases spine fusion is warranted.

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DUODENAL INJURIES

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INJURIES to the duodenum occur infrequently, and it is a distinct rarity that the duodenum alone is damaged. In World War I there were reported ten instances¹ of duodenal injury comprising 6 per cent of all small bowel involvement. The mortality for these ten cases was 80 per cent. The statement is made in the general surgical section of the "Medical History of World War I," that multiple lesions are usually encountered in duodenal injury, the average expected is four to six.

Jarvis,² in his analysis of the abdominal wounds handled by this group in 1943, reports nine cases of duodenal injury with seven deaths. In two cases, the duodenal lesion was missed at operation and in one of these, the missed perforation was the cause of death. These nine cases were marked by the multiplicity of organs involved. In three of the seven deaths reported, the pancreas was involved, in one the vena cava, and in another, the superior mesenteric artery.

For the year 1944 and the active part of 1945, there have been 118 instances of duodenal injury encountered by this group, and these 118 cases are the basis of this study. Three thousand one hundred fifty-four abdominal operations were performed in this period, and duodenal injury was present in 3.74 per cent of the cases. (Table 1.) Of the 1,168 instances of small bowel injury, the duodenum comprises 10.1 per cent of the cases.

Mortality. Mortality in this series is computed upon the basis of the first ten postoperative days. In the 118 cases, sixty-six deaths occurred within the first ten days, a mortality of 55.9 per cent. There are three instances in which death probably occurred within the first ten days, but the records are incomplete.

Site of Entry Wound. The site of the

wound of entry is fairly consistent in duodenal injury. The missile entered the right side of the trunk, either front or back, in ninety-eight or 85 per cent of the 118 cases. Twenty per cent of all wounds were perforating in type. As will be shown later in the discussion of complicating injuries, there is a wound pattern in which duodenal injury may be reasonably expected and sought for. Figure 1 illustrates the approximate area of penetration of the missile in the duodenal injuries of this series and the frequency in actual numbers. (Fig. 1.)

TABLE I
INCIDENCE AND MORTALITY

Gross Totals		
No. Cases	Incidence in 3154 Cases	Mortality Rate (Gross)
118	3.74%	55.9%

Uncomplicated Cases		
No. Cases	Incidence of Cases	Mortality
2	1.6	0

Complicated Cases		
No. Cases	Incidence	Mortality
116	99.4	56.9

There was one case of duodenal injury without penetration. The patient had a large gutter wound across the epigastrium with omentum herniated through the

wound. No wound of exit was present and a foreign body could not be demonstrated by x-ray. It was believed by the operator

Cause of Death. Shock and hemorrhage were the recorded causes of death in thirty-nine or 59.5 per cent of the deaths. Forty-

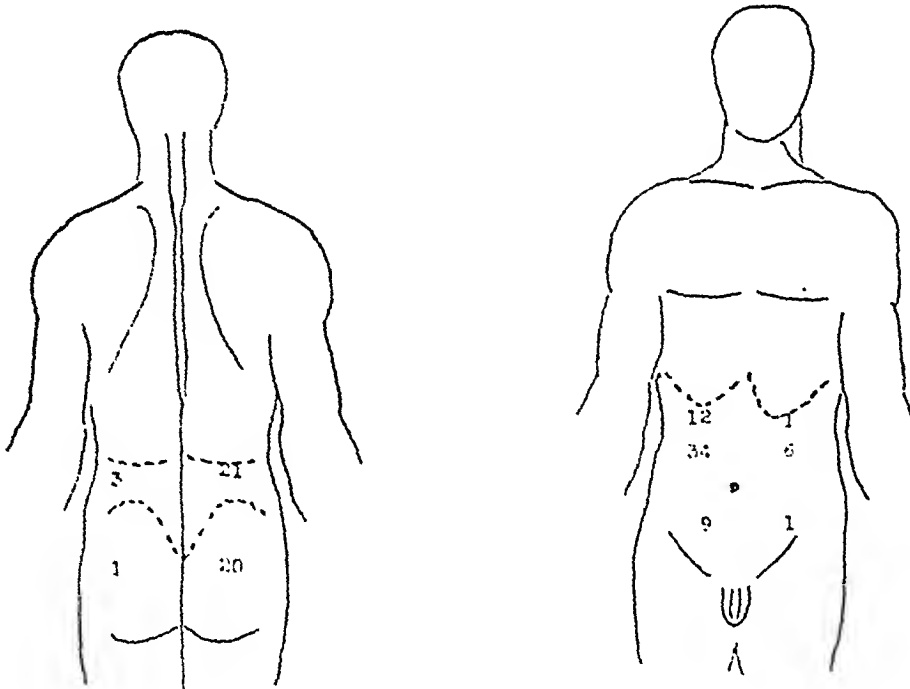


FIG. 1. Site of wound entry.

that the stellate lacerations of the liver and second portion of the duodenum were due to blast.

Shock Record. The shock record upon admission to the hospital is constant in that the patients who subsequently died were in the main in a more severe state of shock than those that recovered. The classification of shock is taken from the records just as recorded. (Table II.)

TABLE II
DEGREE OF SHOCK

Degree of Shock	Lived	Died
None.....	14	6
Mild.....	12	3
Moderate.....	12	8
Moderately severe.....	1	6
Severe.....	9	43

In four instances, the degree of shock was not recorded. Of the nine cases of vena cava laceration, one was in no shock, four in only moderate shock, and four in severe shock.

seven or 71 per cent of the deaths occurred in the first three postoperative days. Two of the deaths resulting from peritonitis were due to injuries overlooked at operation, one a laceration of the common duct, the other, a perforation of the third portion of the duodenum. (Table III.)

TABLE III
DAY OF DEATH AND CAUSE

Cause of Death	At Operation	First 24 Hrs.	24 Hrs. to 72 Hrs.	3 to 10 Days	Totals
Shock and hemorrhage.....	5	25	8	1	39
Pneumonia.....	2	7	9
Anuria.....	2	6	8
Transfusion reaction.....	2	..	2
Pulmonary embolism.....	1	..	1
Peritonitis.....	3	3
No record.....	2	2	4

Complicating Injuries. Multiple complicating lesions are usual in duodenal injuries. There were only two cases of damage to the duodenum alone in this

series of 118, an incidence of 1.6 per cent and both patients survived.

In Table iv are shown the complicating lesions in addition to the duodenal injury in actual numbers. These figures are misleading in that in many instances there are multiple lesions to one organ which are recorded in the table as one; it does not take into account the vascular injuries, and further, the extent of the damage to one organ cannot be shown. (Table iv.)

TABLE IV
FREQUENCY OF COMPLICATING INJURIES

No. of Organs Injured in Addition to Duodenum	No. Lived	No. Died	Mortality, Per Cent
1	12	15	55.5
2	25	20	44.4
3	7	14	66.6
4	5	15	75.0
5	1	1	50.0?

Not included in Table iv were the two cases of duodenal injury alone, and one of duodenum complicated by a portal vein laceration. It is seen that with three complicating injuries, the mortality is doubled and with four, it is tripled. The one case recorded as living with five complicating lesions probably died as he was left moribund on the fourth post-operative day with a holding company.

In Table v is shown the greater number of organ resections required in those patients that subsequently died. (Table v.)

Vascular injuries are not an infrequent complicating wound in injuries to the duodenum. In this series of 118, there were nine, or 7.6 per cent instances of vena cava laceration with eight deaths. There were two cases of portal vein laceration, two of the pancreato-duodenal artery, and one each of the hepatic and right spermatic artery. All of these patients died.

In Table vi are listed the organs most frequently complicating duodenal injury, and the percentage frequency of their involvement. It may be seen from this

chart, that there is a fairly constant wound pattern when the duodenum is injured. If, for example, there is a wound of the right upper quadrant that has involved the right kidney, liver, and right colon, an injury to the duodenum is quite likely. (Table vi.)

TABLE V
ORGAN RESECTIONS

Operation	Lived	Died
Spleneectomy.....	1	4
Cholecystectomy.....	2	6
Nephrectomy.....	9	12
Right colectomy.....	2	7
Resection of small bowel.....	4	9
Gastrojejunostomy.....	0	4

TABLE VI
INCIDENCE OF COMPLICATING INJURIES
TO OTHER VISCERA

	No. of Times Injured	Per Cent
Liver.....	69	58.47
Colon.....	59	50.0
Right kidney.....	37	31.3
Small bowel.....	36	30.5
Stomach.....	21	16.1
Gallbladder.....	17	14.4
Pancreas.....	9	7.6
Vena cava.....	9	7.6
Portal vein.....	2	1.8

The pancreas was involved in 7.6 per cent of the cases in this series. Of the nine cases with pancreatic involvement, eight died. There was only one case in which the pancreatic head was damaged to the extent of severing the duct. Drainage of the damaged pancreas was universally employed, and where possible, the capsule was sutured. All eight of the patients with pancreatic injuries died within the first six days. Fat necrosis was a marked feature in one, both at operation and necropsy.

The gallbladder was injured seventeen times in this series, an incidence of 14.4 per cent. Cholecystectomy was performed

eight times, and the remainder were either sutured, or had a cholecystostomy. Gall-bladder injury occurred almost equally in those who lived, and those who died. However, three times as many cholecystectomies were required among the fatal cases.

Associated Injuries. There were fifteen of the 118 cases of duodenal involvement with an associated chest injury. This varied in severity from a simple perforation of the diaphragm to severe laceration or contusion of the lung. Of the fifteen cases with associated chest damage, eleven died.

It is not within the scope of this paper to discuss shock, but it is clearly shown that two factors contributing to shock, vascular injuries with concomitant hemorrhage and chest injuries with disturbance of cardio-respiratory physiology, play a very important rôle in contributing to mortality in this series.

Colon Complications Other than from Direct Injury. Severe damage to the blood supply of the right colon was not an infrequent injury in this series. There were two instances in which the right colon was not perforated, but right colectomy was done because of an avascular colon. In three instances, loop colostomy was done because of an avascular area, one in the right transverse colon, and two in the ascending colon.

TABLE VII
SITE AND TYPE OF DUODENAL INJURY

Site	Tran- section	Perfo- ration	Lacer- ation
First portion.....	7	12	8
Second portion.....	7	34	14
Third portion.....	1	6	8
Junction of first and second.....	..	2	4
Junction of second and third.....	1	2	2
Duodenal-jejuno junction	4		
	20	56	36

Duodenal Damage. Severe damage to the duodenum *per se* is not frequent. In

only four instances was the damage severe enough to require a short circuiting procedure. Of the four gastrojejunostomies done, all died. In only one instance was the ampulla of Vater damaged, and there was only one of common duct injury. In no case was it necessary to perform a common duct short circuit. Table VII lists the site and type of injuries to the duodenum. In six cases, the type and location were not recorded.

Complications of Duodenal Repair. A discussion of the complications of a duodenal repair is not within the scope of this paper. In most instances, lacerations and perforations of the duodenum were repaired as any small bowel laceration and the technic varied but little among the individual surgeons. Transections of the duodenum were repaired by end-to-end anastomosis with running atraumatic chromic suture in most instances reinforced with black silk or cotton. In almost every case, the site of the repair was drained and universally when complicating pancreatic or liver wounds occurred. In most instances, the peritoneum was closed over the wound. In three cases in which gastrojejunostomy was done, the duodenum was badly damaged and the proximal end was inverted, but none of these lived long enough to develop any possible complications.

There are two known duodenal fistulas that developed in the field hospital. Both of these were transections of the duodenum with an end-to-end anastomosis. Both developed on the sixth postoperative day. There is an additional case that probably developed a duodenal fistula. The record was not complete, but it had been noted on the sixth postoperative day that a clear irritating discharge was draining through the operative wound, and it was the opinion of the observer that a duodenal fistula had developed. This case was a simple laceration of the second portion of the duodenum, repaired by one row of running atraumatic chromic, reinforced with black silk sutures.

There was one case that probably had a duodenal blow-out, but the necropsy was not done. It was the opinion of the officer who saw him at death, that the duodenal suture had not held. The patient had had a through and through perforation of the upper pole of the right kidney that was drained, and a through and through perforation of the second portion of the duodenum that had been closed with two layers of running atraumatic chromic sutures. On the seventh postoperative day, he became markedly distended, and developed severe epigastric pain and expired in eight hours following the onset of these symptoms.

Diagnosis of Duodenal Injury. The preoperative diagnosis of a duodenal injury has no essential differences from that of any intra-abdominal injury. At operation, it was the practice of surgeons of this group always to reflect the right colon and duodenum where there was any suspicion of a duodenal injury. The increasing consciousness of this possibility is shown in that of nine cases of duodenal injury handled by this group in 1943, there were two perforations of the duodenum overlooked. In the 118 cases in this series done in 1944 and 1945, there is only one case of an overlooked duodenal injury. Too much stress cannot be placed upon the advisability of thorough exploration of the duodenum in cases in which there is any possibility that the missile perforated the retroperitoneal space behind the right colon, and this can only be done by reflecting the right colon.

COMMENTS

It is seen that 99.4 per cent of duodenal injuries have complicating lesions. The most frequent organs involved in order were liver, colon and right kidney. In 83 per cent of the cases the missile entered either right back or right abdomen. With these facts in mind it may be reasonably deduced that a missile entering the right side, front or back, and injuring the liver, colon, and right kidney has a very strong

probability of also injuring the duodenum. It is again emphasized that it was the practice of surgeons in this group routinely to reflect the right colon and examine the duodenum thoroughly in any case possessing the wounds as described above and also in any case presenting the probability of a duodenal injury.

Incidence of injury to particular portions of the duodenum was out of proportion to the mass of duodenum and its protection by bony structures such as the vertebra. In 46.6 per cent of this series the second portion was injured. The first in 22 per cent and the third in 12.7 per cent of the cases. In many of the cases of injury to the first portion of the duodenum there was a continuous lesion with the pylorus and similarly in the third portion a continuous lesion of the jejunum. It is surmised that many injuries to the first portion of the duodenum do not survive to reach operation because of the close relationship with the hepatic artery and portal vein and again similarly with the third portion of the duodenum with its close relationship with the aorta, vena cava and mesenteric vessels.

Twenty instances of duodenal transection were encountered in this series. The usual repair was by end-to-end anastomosis with a double layer of chromic catgut reinforced with interrupted black silk. Six of these patients with transections lived through the sixth postoperative day and two of the six developed a duodenal fistula on the sixth day. The frequency of this complication can only be indicated by this small series but it aids in emphasizing the necessity of drainage to a repaired duodenal injury.

SUMMARY AND CONCLUSIONS

1. Injuries to the duodenum are infrequent in abdominal wounds, and very rarely is the duodenum alone involved.
2. In abdominal wounds with duodenal injury, the mortality was 55.9 per cent in 118 cases.

3. In this series, the site of the entry wound was in the right trunk in 83 per cent of the cases.

4. Severe shock was usually present preoperatively in this series.

5. Multiple complicating injuries are usual in duodenal injury. Vascular injuries are not infrequent.

6. It was found that 12.7 per cent of the 118 patients had an associated chest injury.

7. Severe damage to the duodenum is not usual. In only four cases of this series was the damage severe enough to require a short-circuiting procedure. There was only one case of injury of the ampulla of Vater, and in no instance was a common duct short circuit required.

8. There were twenty transections of the duodenum in this series with the development of fistula in two. However, most patients with transections died within the first three days. Six patients with transections of the duodenum lived through the sixth postoperative day. Of these, two developed fistula. There is a strong indication of a high incidence of fistula development in the transected duodenum.

9. It was the practice of the surgeons in this group routinely to reflect the right colon in injuries where there is any reason to suspect a perforation of the duodenum.

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INTRAVENOUS SODIUM PENTOTHAL AS A BASAL ANESTHETIC*

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A PERTINENT problem in modern surgery has been the control of the mental anguish that possesses the patient who is to undergo surgery. Anesthetists know, too well, the screams of the frightened child, the increased pulse rate and blood pressure readings of the near hysterical woman, and the thyroid storms that are precipitated in patients when they are wheeled into the operating suite.

Because of this, and the desire to be humane, anesthetists have tried to minimize the fear of the "terrible unknown" that confronts the preoperative patient. Sedation with opium or its alkaloids or oral barbiturates is not always effective; and although the patient may appear to be cooperative, the application of the mask or the prick of the spinal needle frequently evokes such protests which result in an emotionally upset patient, surgeon, and anesthetist. More anesthetic is required in the excited patient with the attendant undesirable effects.

Basal anesthesia has proved to be more efficacious. It may be defined as the state of unconsciousness produced by a non-volatile agent which should serve as a base upon which a complete anesthesia can be built up by the addition of a general anesthetic agent.⁴ It has as its prime advantages a smoother induction, a requirement for less of the anesthetic agent, and it results in an unfrightened patient in whom there has been a minimum of psychic trauma and resultant shock. However, this method is not without its attendant disadvantages and even dangers. A satisfactory basal anesthetic must be

predictable, controllable, rapidly metabolized or excreted, easily and quickly administered, and must have no deleterious effects on any organ of the body.

The most commonly used basal anesthetics are paraldehyde, avertin (tribromethanol), and the drugs of the barbiturate group. Paraldehyde is safe from the anesthetist's point of view, but is unsatisfactory by reason of its repellent odor which persists for a long time on the patient's breath and by the need for administering it by rectum in large bulk, diluted with saline.

Avertin is neither predictable nor controllable. The same dose may, in one patient, produce a profound narcosis lasting twelve or more hours and, in another patient, cause excitement, thereby defeating the purpose for which it was intended. Doubtless these bizarre effects are due to the variation in the rate and ability of absorption and tolerance by the rectosigmoid colon of each individual. Avertin is metabolized primarily in the liver, and according to Hill⁵ it can cause liver damage in a manner similar to chloroform. He believes this is due to their similarity in chemical structure. It is also contraindicated in the presence of rectal or colon disease. Mousel and Lundy¹⁵ warn against oversedating a patient so that his respiration becomes so shallow that he cannot inspire sufficient anesthetic agent to produce relaxation. This effect has been noted with avertin. Also, it may often abolish the cough reflex.⁶ Such shallow respirations may persist postoperatively requiring more nursing care and despite this may lead to an increase in pulmonary complications.⁸

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Sise²¹ found avertin to be less controllable than the barbiturates.

The search for a basal anesthetic more approaching the ideal has lead anesthetists to experiment with barbiturates for this purpose.⁷ That barbiturates can be safely combined with inhalation anesthetics has been amply proven.^{3, 10, 16, 19, 20} Gwathmey gave nembutal by mouth and by rectum to children and noted elimination of preoperative fear, easier induction and maintenance of anesthesia, earlier return of throat reflexes, and absence of postoperative nausea and vomiting. Hudson¹³ was forced to supplement unsatisfactory intravenous evipal anesthesia with ether in three small children and observed no untoward effect but, on the contrary, a very smooth induction resulted. He concluded that induction was more rapid with evipal than with avertin, and that a further advantage was the more frequent production of relaxation.

Organe and Broad reported 236 cases of combined pentothal and nitrous oxide-oxygen anesthesia noting smoothness of induction. Borthwick¹ used barbiturates preoperatively in children with gratifying elimination of screaming and thrashing about. Previously, such drugs of the barbiturate series as somnifene, sodium amytal, pernocton and rectidon were much used as basal anesthetics in Europe.^{6, 8, 18}

With the advent of shorter acting, more rapidly destroyed barbiturate derivatives such as evipal and sodium pentothal, which could be given intravenously, attention was turned to this less bothersome, quicker, and more controllable method of providing basal anesthesia.^{8, 23} Machray¹⁴ advised supplementing the routine morphine and scopolamine with intravenous evipal on the operating table before beginning the inhalation anesthetic. Goldman⁶ and Clausen⁴ injected sodium pentothal intravenously while the patient was still in his bed, and then moved him, calmly sleeping, to the operating room.

Brooks,² who was dealing with patients who had been in combat and due to psychic

and physical trauma therefore, were hard to handle, found that intravenous sodium pentothal was an ideal inducing agent. Mousel and Lundy¹⁵ advised putting extremely nervous patients to sleep in bed with intravenous pentothal in 2½ per cent concentration prior to removing them to the operating room.

Hudon¹¹ described his technic of administering 5 to 10 cc. of a 2 per cent sodium pentothal solution intravenously and immediately following it with cyclopropane-oxygen inhalation. Although this was primarily a method of balanced rather than basal anesthesia, he cited among its advantages a rapid, smooth induction and a decrease of postoperative nausea.

Elliot and Arrowood⁵ also described a combined method of intravenous pentothal and nitrous oxide oxygen anesthesia for use in oral surgery.

Hudson¹³ and Thomas²² used intravenous sodium pentothal to put the patient to sleep before moving him to the operating room.

At our hospital we have used the following technic of administering basal anesthesia in adults. One hour preoperatively scopolamine gr. ¼₁₅₀ to ¼₃₀₀ is given by hypodermic. Morphine is not used both because it is unnecessary and because of the respiratory depression that it causes. In many cases, and especially in cases scheduled for thyroidectomy, the patients do not even know that they are to be operated on that day. Fifteen minutes preoperatively the anesthetist enters the patient's room carrying, as sole equipment, a rubber tourniquet and a 20 cc. syringe containing a freshly prepared 2½ per cent sodium pentothal solution. After a cheerful greeting the patient is asked to hold out his arm so that a sample of blood for "analysis" may be taken. Having had a previous workup, this causes no undue fear or excitement in the patient.

The needle is inserted in the vein and after a 1 cc. test dose has been given, and

its effects observed for thirty seconds, 2 to 5 cc. are slowly injected. Conversation is maintained with the patient until he has fallen into a light sleep. We do not "push" the drug to the point where the reflexes are abolished. We merely want the patient to go to sleep. As soon as this occurs, the nurse and orderly, who are waiting outside the door, are called; the stretcher is wheeled in and the patient is rapidly transported to the operating room and placed on the table. Anesthesia with cyclopropane is then begun and continued to the point where ether can be given without causing cough, or is continued as cyclopropane-oxygen with or without intratracheal intubation. We have also followed this basal anesthetic with a spinal anesthetic and have then used a continuous sodium pentothal drip during the operation to maintain sleep.

COMMENT

We believe this method of basal anesthesia to be superior to any previously employed. It is safer, more controllable, and more predictable than either paraldehyde or avertin by rectum. The sodium pentothal is rapidly metabolized by the body tissue and does not persist in the patient postoperatively as do the others. Our patients have no undue depression of respiration, have a quicker return of reflexes and wake up more rapidly; all of which make for less postoperative pulmonary complications and the need for already scarce extra nursing care. We have used this method successfully in thyroidectomies, amputations of breasts for malignancy, breast plastics, and various gynecological operations all of which are done in patients who are "normally" excitable and in whom an abnormal fear of the operating room exists.

Contraindications to the use of this method are marked anemia, hypotension, cardiac, respiratory, luetic, or allergic disease. It has a wider range of use than avertin, being useable in colon surgery, which contraindicates rectal anesthesia,

and it may be used even in the presence of hepatic disease, since it has been shown that Sodium Pentothal is broken down by all the body tissues and not by the liver exclusively as was formerly believed.¹⁵

Our surgical staff is pleased by the quiet induction, and above all, our patients gratefully tell us that they awaken to find the "horrible" expectancy of operation a fait accompli.

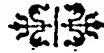
SUMMARY

1. Basal anesthesia is a useful and often necessary procedure in the armamentarium of modern surgery.
2. The properties of a desirable basal anesthetic are given.
3. The various methods of basal anesthesia are discussed.
4. The superiority of intravenous sodium pentothal as a basal anesthetic is presented with a review of the pertinent literature.
5. A technic of basal anesthesia utilizing intravenous sodium pentothal is given.

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MANY minor operations in the mouth can be performed under local anaesthesia, but if the operation is expected to occupy some length of time and bleeding to be free it is wiser to give a general anaesthetic, preferably with the introduction of an intratracheal catheter.

From "Minor Surgery" edited by Humphry Rolleston and Alan Moncrieff (Philosophical Library).

DOES ANTERIOR GASTROJEJUNOSTOMY PREDISPOSE TO DEVELOPMENT OF JEJUNAL ULCERATION?*

A STUDY BASED UPON NINETY PARTIAL GASTRECTOMIES

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WITH the gradual shift of surgical opinion in the past twenty years away from short circuiting operation for "peptic ulcers" to sub-total gastrectomy, different types of operation were proposed. There has been a gradual evolution of surgical technic beginning with the Billroth I to the present day Polyá, Polyá-Balfour, Moynihan, Mikulicz, Hoffmeister-Finsterer operations. In general, it has been found to make little difference just which type of resection and anastomosis is made provided the method is sufficiently radical to permit of wide resection.

There appears to be some controversy of opinion as to whether an anterior gastrojejunostomy or a posterior gastrojejunostomy should be done. Each type of operation has its proponents. It has been said that the anterior gastrojejunostomy, although much simpler to perform, is not as satisfactory as the posterior gastrojejunostomy since the jejunal mucosa much further removed from the stomach is exposed to an unaccustomed gastric content and hence the danger of jejunal ulceration development is greater.¹ This group would have us believe that because the posterior gastrojejunostomy utilized a loop of jejunum much closer to the stomach, its mucosa was much better able to receive the insult of direct reception of gastric contents.

We have undertaken this study based upon ninety partial gastrectomies for "peptic ulcer" in an effort to determine whether the anterior gastrojejunostomy

does predispose to the development of a jejunal ulcer. If it can be shown that the mucosa of the jejunum 30 cm. from the ligament of Treitz is as resistant to the irritating effect of the gastric contents as that much closer to the ligament, then that particular objection to the anterior gastrojejunostomy would cease to exist. The ease with which an anterior gastrojejunostomy can be done as compared to the posterior gastrojejunostomy and its absolute freedom from the danger of injury to the middle colic artery, which may occur during the posterior gastrojejunostomy, would indeed make it the procedure of choice in all partial gastrectomies.

In our series of ninety cases, we used the anterior Polyá type of anastomosis. Seven of the cases required a Hoffmeister modification of the Polyá technic. This modification was found very useful in those cases in which the lesion was unusually high up on the lesser curvature and a safer anastomosis could be made by closing a part of the stomach stoma. A long loop of jejunum was brought anterior to the transverse colon and the point of anastomosis was made 30 to 40 cm. from the ligament of Treitz. In all of our cases, we removed sufficient stomach to create a postoperative achlorhydria or hypochlorhydria. In order to standardize our operative technic as far as is possible we used as the upper line of our gastric incision, the point at which the left gastric artery reaches the lesser curvature, and the lower line of the incision reaches the bare (avascular) area of the stomach which is

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seen between the left and the right gastro-epiploic arteries. (Fig. 1) By removing all the stomach distal to the line of incision

est patient was twenty-two years old, and the oldest was seventy-two. Both patients had excellent results from the operations

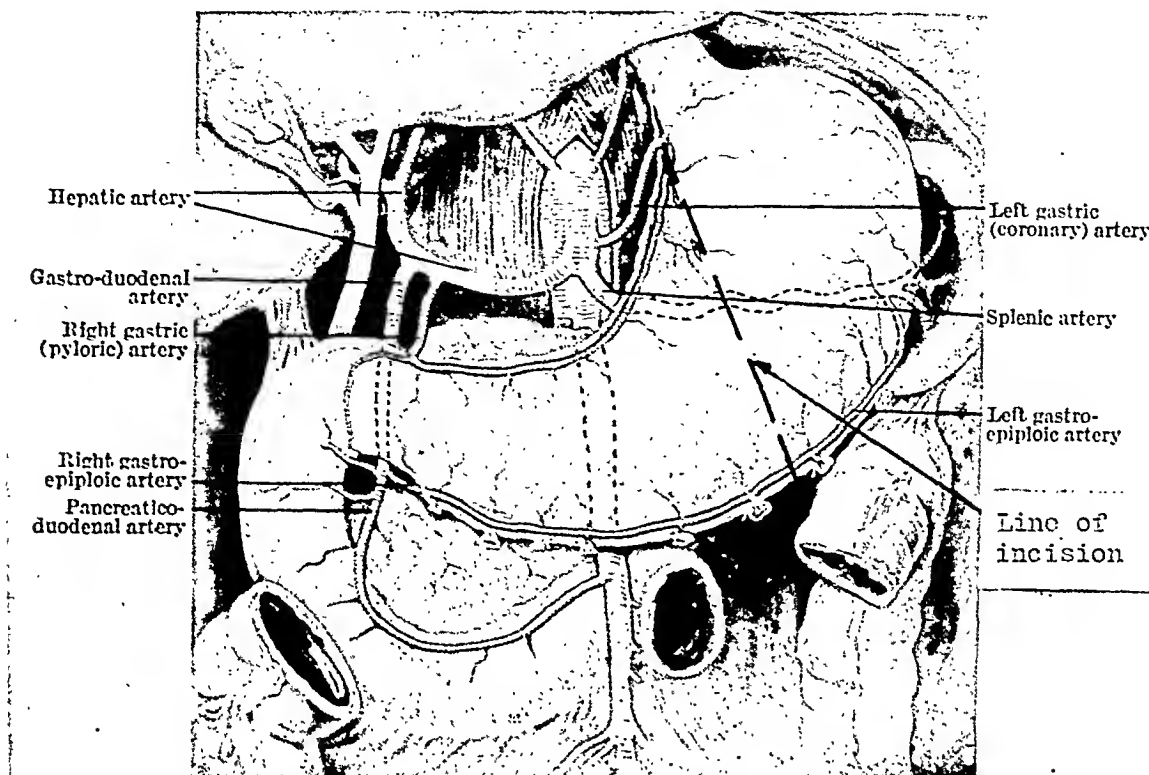


FIG. 1. Note the line of incision between the point at which the left gastric artery meets the lesser curvature and the bare area between the right and left gastro-epiploic arteries. (From Maingot, R. Technique of Gastric Operations.)

just described, all the stomach that is necessary to be removed for a good result was excised. In this way, all the acid-forming tissue was removed from the stomach and also the antral mucosa which appears to regulate acid secretion.² Since all the acid-forming tissue has been removed at operation, we have been able to produce an achlorhydria with the result that the irritating effect of the hydrochloric acid from the gastric secretion cannot be considered a factor in the production of jejunal ulcers postoperatively. With the removal of this chemical factor as a possible etiological agent in the production of jejunal ulcers, we are left only with the mechanical irritative factor resulting from the discharge of gastric contents onto a jejunal mucosa which is not accustomed to it.

A glance at the tabulated histories reveals some interesting data. Our young-

performed. Eighty-two of the patients were males and only eight were females. Sixty-nine of the patients were operated upon for duodenal ulcer and twenty-one patients had gastric ulcers. The largest number of patients were between fifty to sixty years old. The age of the patient in no way influenced the decision to do a partial gastrectomy. It is the physical condition of the patient that determined the operability. We did not perform an entero-enterostomy in a single case in association with our anterior gastrojejunostomies. Many of these patients were operated upon five years ago so that adequate time has elapsed for jejunal ulceration to develop if this operation predisposed to it.

In our follow-up of these ninety patients, we found not a single patient had developed a jejunal ulceration. When we compare this with studies taken from various surgical centers throughout the country

TABLE I
PATIENTS OPERATED UPON*

Name	Sex	Age	Diagnosis
1. H. C.	M	22	Duodenal ulcer
2. L. B. M.	F	27	Gastric ulcer
3. J. K.	M	27	Duodenal ulcer
4. J. K.	M	27	Gastric ulcer
5. S. I. G.	M	30	Duodenal ulcer
6. G. N.	M	32	Duodenal ulcer
7. G. H.	M	32	Duodenal ulcer
8. W. W. B.	M	31	Duodenal ulcer
9. H. L.	M	34	Gastric ulcer
10. J. C.	M	38	Duodenal ulcer
11. C. H.	F	39	Duodenal ulcer
12. A. L. T.	M	40	Duodenal ulcer
13. W. F. G.	M	41	Gastric ulcer
14. C. M.	F	41	Duodenal ulcer
15. T. S.	M	41	Duodenal ulcer
16. E. E.	M	41	Gastric ulcer
17. H. A.	M	42	Duodenal ulcer
18. J. B.	M	43	Duodenal ulcer
19. R. T.	M	43	Duodenal ulcer
20. M. B.	M	43	Gastric ulcer
21. C. M.	M	44	Duodenal ulcer
22. H. G.	M	44	Duodenal ulcer
23. T. J.	M	45	Duodenal ulcer
24. L. V.	M	45	Duodenal ulcer
25. G. A.	M	44	Duodenal ulcer
26. R. S. L.	M	46	Duodenal ulcer
27. W. M.	M	47	Gastric ulcer
28. S. J. M.	M	47	Duodenal ulcer
29. A. W.	M	47	Duodenal ulcer
30. D. H.	M	47	Duodenal ulcer
31. J. H. M.	M	47	Duodenal ulcer
32. H. L.	M	48	Duodenal ulcer
33. A. B.	M	48	Duodenal ulcer
34. J. B. E.	M	49	Duodenal ulcer
35. O. E. H.	M	47	Gastric ulcer
36. A. P.	M	48	Duodenal ulcer
37. C. T. W.	M	48	Duodenal ulcer
38. F. B.	M	50	Gastric ulcer
39. C. B.	F	50	Duodenal ulcer
40. M. F. F.	M	50	Marginal ulcer
41. W. G.	F	50	Duodenal ulcer
42. A. M.	M	51	Duodenal ulcer
43. K. H.	M	51	Duodenal ulcer
44. E. D. S.	M	51	Duodenal ulcer
45. E. M.	M	51	Gastric ulcer
46. L. B.	M	51	Duodenal ulcer
47. J. M.	M	52	Duodenal ulcer
48. A. M.	M	52	Duodenal ulcer
49. F. K.	M	52	Duodenal ulcer
50. W. B.	M	53	Duodenal ulcer
51. I. W.	M	53	Duodenal ulcer
52. J. J.	M	54	Duodenal ulcer
53. K. K.	M	54	Duodenal ulcer
54. C. W. G.	M	54	Gastric ulcer
55. K. H.	M	55	Duodenal ulcer
56. H. M.	F	55	Duodenal ulcer
57. F. G.	M	55	Duodenal ulcer
58. W. P. M.	M	57	Duodenal ulcer
59. G. M.	M		

TABLE I (Continued)

Name	Sex	Age	Diagnosis
60. H. B.	M	56	Gastric ulcer
61. E. E.	M	56	Duodenal ulcer
62. M. S.	F	56	Gastric ulcer
63. I. H.	M	58	Gastric ulcer
64. R. R.	M	58	Duodenal ulcer
65. A. W.	M	59	Gastric ulcer
66. T. P.	M	59	Duodenal ulcer
67. J. H. C.	M	57	Duodenal ulcer
68. A. B.	M	57	Gastric ulcer
69. C. E.	M	57	Duodenal ulcer
70. J. L.	M	34	Duodenal ulcer
71. M. C.	M	51	Duodenal ulcer
72. J. W.	F	36	Duodenal ulcer
73. L. P.	M	51	Duodenal ulcer
74. H. W.	M	60	Duodenal ulcer
75. W. H.	M	60	Gastric ulcer
76. M. D.	M	61	Duodenal ulcer
77. T. H. H.	M	61	Gastric ulcer
78. J. D.	M	62	Duodenal ulcer
79. G. A. H.	M	62	Gastric ulcer
80. H. F.	M	62	Duodenal ulcer
81. J. C. C.	M	64	Duodenal ulcer
82. J. K.	M	66	Duodenal ulcer
83. G. M.	F	66	Duodenal ulcer
84. J. G.	M	71	Gastric ulcer
85. D. W. O.	M	77	Duodenal ulcer
86. E. G. B.	M	72	Duodenal ulcer
87. G. P.	M	47	Duodenal ulcer
88. H. W.	M	56	Duodenal ulcer
89. A. K.	M	53	Duodenal ulcer
90. R. C.	M		

* The operation in each case was sub-total gastrectomy and all the patients recovered.

performing posterior gastrojejunostomy, it becomes evident that the results we obtained at Grace Hospital are quite favorable. In performing our sub-total gastrectomies, we always make it a point to fasten the proximal loop of jejunum to the lesser curvature just above the anastomosis for a distance of 3 cm. This suture prevents regurgitation of the stomach contents into this proximal loop of jejunum.

COMMENT

Any method of gastrojejunostomy which can be performed with a minimum of hazard should be the operation of choice. Since sufficient gastric acid-forming tissue and the antral mucosa is removed at operation to render the gastric contents relatively achlorhydric postoperatively, it

makes little difference from a chemical irritant point of view as to whether the mucosa of a short loop or a long loop of jejunum is exposed to the gastric contents. We have been able to demonstrate in our series of ninety cases that the mucosa of a long loop of jejunum can withstand the mechanical irritating effects of the gastric contents as well as the mucosa of the short loop of jejunum. The choice of operation would depend then upon which could be done with greater safety. The posterior gastrojejunostomy becomes very difficult in a patient having a short mesocolon or a very fatty mesocolon so that the middle colic artery cannot be readily identified. An injury to the middle colic artery in the performance of a posterior gastrojejunostomy does occur even in the best surgical centers.³ This necessitates resection of the colon and thus adds to the operative morbidity and risk. If the anastomosis is performed to the right of the middle colic artery instead of to the left, the results are not too good. By the use of the anterior gastrojejunostomy all these pit-falls are avoided; and since we have demonstrated that the anterior gas-

trojejunostomy does not predispose to the development of jejunal ulcers, we believe it to be the operation of choice. In no case did we perform an entero-enterostomy with the gastrojejunostomy.

CONCLUSION

1. Anterior gastrojejunostomy does not predispose to the development of jejunal ulcers.
2. The mucosa of the jejunum in the long loop is able to withstand the effects of receiving the gastric contents directly as well as the mucosa of the jejunum closer to the stomach.
3. By using the anterior gastrojejunostomy, without entero-enterostomy, all danger of injury to the middle colic artery is avoided.

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FINGER AMPUTATIONS*

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FINGER amputations are common surgical operations. They may be considered minor or major depending upon the extent and severity. It is certain that the uncomplicated amputation of the distal portion of a phalanx is a minor surgical procedure, but extensive injury to the entire finger or fingers demands surgical skill and judgment necessary for the preservation of the maximum residual function. It has been stated that next to the brain, the hand is the greatest asset of man, and to it is due the development of man's handiwork. It is also an organ of expression and a special sense organ for stereognosis.

Finger amputations occur in all age groups. They are more frequently observed in the adult male whose hands are subjected to injury associated with occupation. Therefore, the industrial surgeon will be frequently confronted with this surgical problem. The common causes for finger amputations are trauma, deformity, and infection. Finger amputations caused by trauma take first place in the list of etiological factors. Among the indications are: (1) Severe soft tissue damage with destruction of skin, fascia, and tendons; (2) multiple compound comminuted fractures with or without soft tissue destruction; (3) burns, second and third degree; (4) gangrene occurring from the use of certain chemical agents; viz., aluminum acetate, phenol, and bichloride dressings; and (5) frost bite.

Many severe freshly traumatized fingers demand primary amputation. The immediate judgment in such cases implies that all efforts to save the digit are obviously of no avail. The large majority fall

into this group. Amputations are in many instances done without the patient's knowledge or consent. The honest evaluation of the attending surgeon must be depended upon as to what is best. In other less severely damaged fingers, painstaking management may result in a disability which renders the digit useless, and inhibits the maximum functions of the remaining fingers. Amputation is to be considered in this type of case. One must always bear in mind the function of the repaired traumatized digit, that it should be compatible with the maximum residual function. A stiff frozen finger is of no value in work or industry where digital dexterity is of great importance. If the amputation is one of election, complete agreement between the surgeon and the patient is demanded. The question of the patient's desire for amputation on the basis of obtaining financial reimbursement must ever be borne in mind, but in the vast majority of cases, election of amputation will be based on a disability evaluation that is honest.

Most secondary amputations are done at the request of the worker, who preferred no finger to a useless one.

Fingers subjected to third degree burns producing tissue destruction that is irreparable, indicate amputation primarily. Many severe second degree burn cases rendering the finger useless, come to amputation. The advances in dermoplastic procedures in these cases have done much to preserve useful function, and such operations should be considered before amputation is elected.

The use of aluminum acetate, phenol, and bichloride dressings should be dis-

* Presented at the Fourth Annual Conference on Industrial Medicine and Surgery, Division of Traumatic Surgery, Long Island College of Medicine, Brooklyn, New York, January 31, 1946.

couraged. If moist dressings are indicated, boric acid or magnesium sulfate is preferable.

Fingers are common sites of frost bite. There is permanent contraction of the vessels with pallor and numbness of the fingers. Subsequent local management should be followed first. Inevitable gangrene indicates amputation.

Deformity frequently occurs secondarily to the severe trauma previously mentioned. This may be of all degrees as stated, and involve the soft and bony structures independently or in combination. Deformity may occur secondary to tendon loss or tendon function loss. In a series of 233 finger amputations done during the period 1935-45 at the Chevrolet Motor Company, Flint, Mich. plant, 8% of whole finger amputations were performed because of unsuccessful tendon healing. It may be due to joint ankylosis either associated with joint destruction from trauma or secondary infection, or both. Ankylosis may occur in flexion or extension, and may involve one or more joints. The digit becomes a foreign body that is useless, individually, and constantly interferes with adjacent finger and hand function. There are frequently associated intractable pain and circulatory changes.

Massive progressive destructive osteomyelitis with adjacent tendon involvement indicates amputation. The hazard of joint involvement and ankylosis rendering the digit useless is ever present. The sulfonamides and penicillin have reduced these conditions to a considerable extent.

The several functions of a hand are described as tactile sense, pick up, grip, and hook. When amputations are to be done, these several functions should be considered. The occupation of the individual should be taken into consideration when decision for amputation is made. A skilled artisan needs tactile sense and pick up. The common laborer needs grip and hook. Tactile sense is obviously lost with finger amputations, as this function is associated with the finger tips. Finger

amputation stumps may develop a minimum of return of this function. The pick up function combines the activities of the thumb and fingers. The thumb is the most important digit of the hand, and it enters into part of all the functions of the hand. When it is the seat of any indication for amputation, a careful appraisal of the amount to be removed should be made. Maintenance of pick up function preserves a means by which skilled artisans may carry on. The index finger, ring, fourth and fifth fingers are named in order of their importance to preserve this important function in combination with the thumb. The ideal pick up is by use of the thumb and index finger. The remaining fingers enter into this function in order of their location, as mentioned.

Grip or grasp is the most important function of the hand, with pick up in second place. The former involves the firm coordinated use of the intrinsic and extrinsic muscles. The latter calls for their delicate and dexterious action. Grip or grasp is essential to the heavy duty laborer. Pickup is necessary for the skilled artisan. Both functions overlap in their importance. Absence of the thumb at the carpal-metacarpal joint leaves a hand with finger grip alone. This is a weak hand. Preservation of a portion of the first metacarpal helps. A short proximal phalangeal stump assures a reasonably satisfactory grip. Lost motion of the metacarpal phalangeal joint occurs less often, but does result from direct infection, severe primary destruction, and secondary tendon fixation. The metacarpal phalangeal joints should never be sacrificed unless all efforts at satisfactory preservation of function fails. The knuckle line should be preserved, if possible, as this aids grip. If amputation of all fingers is under consideration, short finger stumps will maintain the knuckle line. One should constantly bear in mind the saving of as much as possible. If ankylosis occurs with the metacarpal phalangeal joints in extension, a hook hand results; grip is lost; pick up and hook

functions remain; this hand is inadequate for heavy duty; adjusted occupation is necessary.

The most careful judgment is necessary to avoid removal of too much of the hand. In many instances tissue that upon first examination appeared to be hopelessly injured, will heal with a reasonably satisfactory result. A single finger or portion thereof and a functioning thumb, for example, are always superior to any artificial device. If the disability involves the index finger and is complete, with involvement of all joints, amputation is best done in the mid-metacarpal area. This insures a better muscle pad and cosmetic result. The second finger then assumes the duty of the first. If the disability involves the second finger, the same procedure is indicated with the same results. If the middle and fourth fingers are involved, amputations at the proximal ends of the first phalanges are advised in preference to disarticulations. Disarticulations give unsatisfactory results anywhere. One should avoid metacarpal phalangeal joint excisions of the ring and fourth fingers to prevent the v-shaped deviation of the adjacent fingers.

Short dorsal and long palmar flaps are preferable. Flaps should be made of sufficient length to secure a satisfactory pad, although a short flap can sometimes be used when there is an attempt to save as much of the finger as possible, and utilize adjacent tissue that appears viable. When finger tips are traumatically amputated, and revision of flaps is indicated, utilize as much of the skin on the palmar surface as possible, as this partially preserves tactile sense. Split thickness skin grafts have been used successfully for stump coverage. Bone should be cut smoothly and periosteum should be removed from the severed ends. Nerves are divided high. Tendons are severed and allowed to retract. The intrinsic muscles will be sufficient for stump function. Immobilization of stumps has occurred when tendons were sutured over the bone ends. Good hemostasis is essential, and drainage instituted when infection is anticipated.

Cases are obviously individualized and management must be conservative and concentrated. By attention to the essential details of this common surgical problem, many subsequent plastic and reconstruction operations are eliminated.



INTERLAMINAR SPINAL ANESTHESIA*

AN ALTERNATIVE LATERAL APPROACH FOR SUBARACHNOID PUNCTURE

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IN the routine administration of spinal anesthetics, the usually adopted posteromedian lumbar interspinous approach proves suitable in most instances. However, in the average experience, difficulties are encountered in introducing the spinal needle according to standard recommendations with sufficient frequency to warrant occasional utilization of a satisfactory, although little known alternative method.

Interlaminar, or sublaminar lumbar puncture is a relatively simple and easy procedure that may be resorted to when initial median interspinous puncture is difficult or unsuccessful. On occasion, anesthetists, faced with spinal canals apparently impenetrable between lumbar spines, have suggested abandonment of spinal for a general anesthetic. In such instances, substitution of the interlaminar approach will secure for the surgeon the desired technical advantages of intrathecal anesthesia.

We do not offer this as a new maneuver. Dr. John Linder, who was director of the surgical service at the Beth-El Hospital, and who retired from active practice several years ago, often used the lateral route, and occasionally, when he encountered difficulty, angled his needle and slid it along the bony lamina into the subarachnoid space. It is quite possible also that earlier investigators experimented with this maneuver of thecal ingress. At the present time, however, the method appears to be very little known and in almost complete disuse. Search of a considerable body of the available literature since the time of Quincke¹⁰ and other pioneers in spinal anesthesia, discloses no mention of the procedure.^{1,2,3,4,5,7,8,9,14} For this reason, the

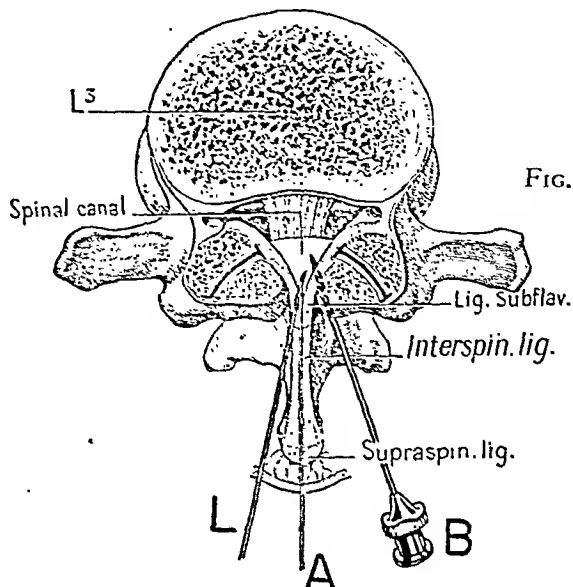


FIG. 1.

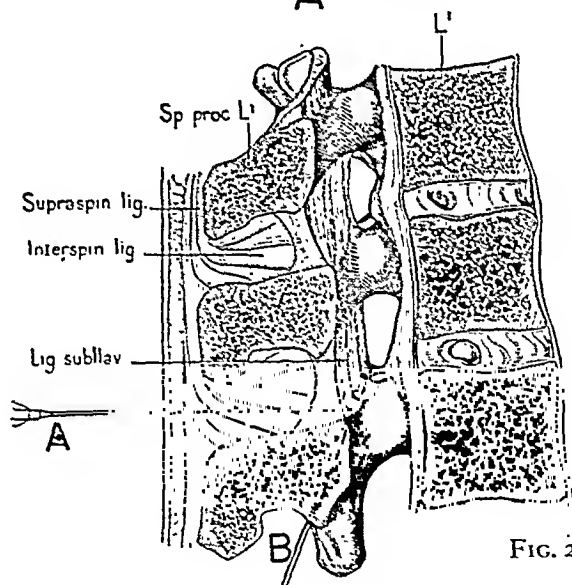


FIG. 2.

FIGS. 1 and 2. Figure 1 is a cross section and Figure 2 a sagittal section of the lumbar spine. Modified from Labat "Regional Anesthesia," by permission of W. B. Saunders Company. A, conventional interspinous approach. The direction of the needle is perpendicular to the surface of the skin, between the spinous processes through the supraspinous and interspinous ligaments. B, Interlaminar approach. Angular direction of the needle along the spinal lamina through the much thinner ligamentum subflavum. L, Lateral approach. Needle is perpendicular to the skin lateral to the spinous processes and directed medially.

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authors believe that publication is indicated to draw attention to this generally overlooked avenue for thecal ingress.

or on one side, just as in the usual manner. However, maximal flexion is not as essential, since separation of the spines is not

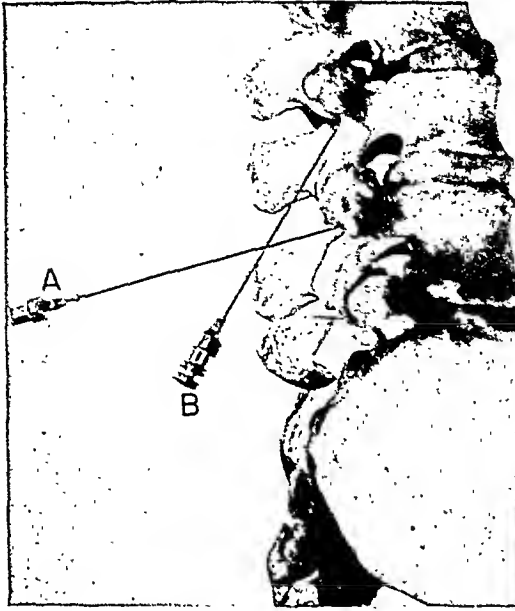


FIG. 3. Lateral view.



FIG. 4. Posterior view.

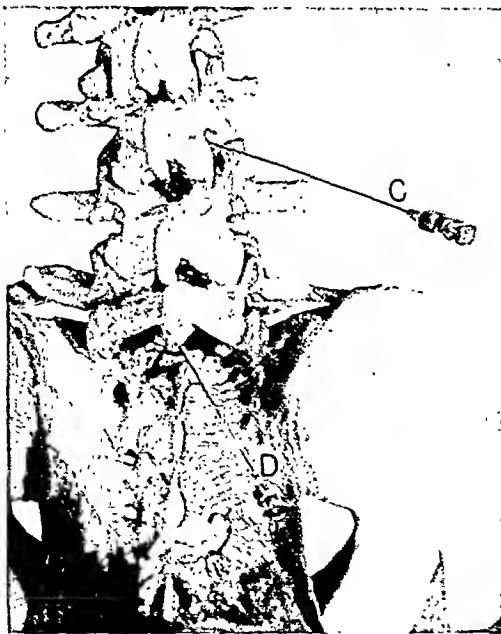


FIG. 5. Oblique view. Regional bony anatomy of approach to lumbar subarachnoid space (Figs. 3 and 4) through: A, conventional interspinous route; B, interlaminar route; in Figure 5, C, through intervertebral foramen; D, lumbosacral space.

In carrying out the procedure, the patient's back is arched, whether sitting up

necessary, and the increase in the interlaminar bony gaps is only moderately augmented as the lower spine is made convex. The procedure can, therefore, be carried out in the ventral prone position. The interlaminar space between vertebrae is narrower laterally than medially, but is wide enough to permit facile entry of the tip of the spinal needle for the required distances. A comparatively long spinal needle, e.g., 10 to 15 cm. of the usual gauge, is introduced subcutaneously about 1.5 cm. to 2 cm. lateral to the tip of the fourth or fifth lumbar spinous process. It is then directed cephalad and forward and slightly medially at an angle of approximately 30 to 45 degrees with the plane of the skin overlying the vertebral column and advanced until bone or spinal fluid is encountered. When bone is encountered, and it usually is, the needle is made to glide forward along the lamina by a to-and-fro movement, slightly varying the angle and advancing gradually until the laminal hiatus is reached. The lower border of the superior lamina may engage the trocar, guiding it into the subarachnoid space. The usual

3½ inch spinal needle may have to be inserted all the way up to the hub. The possible risk of entering the cord proper or the

In the technic of lumbosacral subarachnoid tap presented by Taylor¹² in 1940 for urologic cases, and more recently

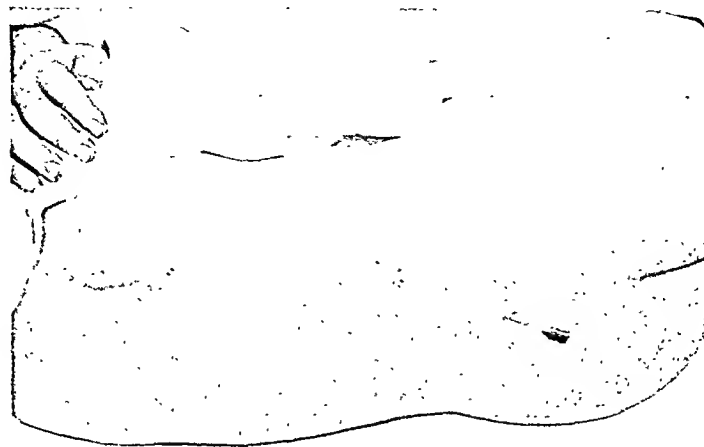


FIG. 6. Photograph illustrating proper direction of the needle 1.5 cm. from the midline at the level of the crest of the ileum, at an angle of about 40 degrees directed cephalad, forward and slightly medially.



FIG. 7. Lateral x-ray view of spinal needle in second lumbar space. Note that spine need not be flexed.

spinal canal does not exceed that of the interspinous course. The fundamental distinction to be kept in mind is that in this technic the direction and course of the needle are determined by the slanting position of the vertebral laminae, and not by the horizontal direction of the spinous processes.

The accompanying illustrations demonstrate the regional bony anatomy and the proper direction of the needle. It is well to bear in mind that the needle enters the subarachnoid space a vertebra higher than the level of puncture of the skin.

redescribed by Schuetz¹¹ for operations on the rectum, bladder, prostate and vagina, the slant of the dorsal surface of the sacrum is similarly utilized. The patient is in the ventral prone position. The skin is punctured at a point 1 cm. below and 1 cm. medial to the lowermost prominence of the posterior superior iliac spine. A long needle is directed upward and medially at an angle of about 55 degrees toward the level of the spine of the fifth lumbar vertebra. The needle is guided by the dorsal surface of the sacrum and enters the lumbosacral space at the midline.

Lateral spinal puncture is described as a method of puncture in which the spinal needle is introduced to one side of the mid-



FIG. 8. X-ray of spinal needle guided by the lamina into subarachnoid space in ventral prone position, obese patient. Note length of needle (6 inches).

line, perpendicular to the skin, and guided medially so as to penetrate the canal at approximately the median line. The spinal meningeal venous plexus is supposedly avoided at this site, and in avoiding an entirely central course, the needle does not traverse the complete depth of the supraspinous and interspinous ligaments, both of which are well developed in the lumbar region. We have found that venous bleeding is induced less frequently by the interlaminar technic proposed than in the usual lateral or dorsomedian routine. Furthermore, the interlaminar ligaments or the ligamenta flava, which are penetrated by the interlaminar approach, are considerably thinner than the supraspinous and interspinous ligaments, which are thus avoided.

Where flexion of the patient is difficult or impossible, as in the cardiac, or in the fused spine, or in general peritonitis, or when the patient must remain prone, interlaminar

subarachnoid puncture may be performed without hindrances otherwise met. In cases in which osteoarthritis bridging is present, a suitable space can generally be found between two lower lumbar laminae even if the spine cannot be flexed at all, or even in opisthotonos.

In no case have the authors found it necessary to forego spinal anesthesia solely because of a mechanically unsatisfactory or difficult subarachnoid puncture, since where one method failed, the alternate procedure was successful. This avenue of approach may also be utilized for fractional spinal anesthesia by the method of Lemmon⁶ using the malleable needle, or by using the ureteral catheter as described by Tuohy.¹³

SUMMARY

An interlaminar approach for spinal subarachnoid puncture and its advantages are described. The method is recommended as an alternate to the usual interspinous mode of administering spinal anesthesia.

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FURTHER EXPERIENCE WITH CONTINUOUS CAUDAL ANALGESIA IN OBSTETRICS*

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OBSTETRIC analgesia in the form of continuous caudal block has been adopted by us as the method of choice for relief of pain during labor. Our preliminary report¹ dealt with the results in 250 patients showing that its use facilitates cervical dilatation, permits normal descent of the presenting part, is adequate anesthesia for delivery, diminishes blood loss, and has no untoward effect on the parturient or fetus. We also emphasized that the immediate postpartum course was smooth, uncomplicated and differed in no respect from the course following the use of any other method of analgesia. These results previously reported and those herewith presented were accomplished by providing adequate personnel and proper team work between the "caudalist" and the accoucheur. Such cooperation and the constant watching throughout labor and delivery is of utmost importance in the safe and effective administration of this type of obstetric analgesia.

We have not deviated from the method of administration of continuous caudal analgesia as originally described by Hingson and Edwards.² Metycaine (1.5 per cent) is used and it is introduced through a malleable needle (No. 19 G.). We discontinued the routine use of ephedrine in the metycaine solution because of increased bleeding during the delivery, particularly from the pelvic floor lacerations or episiotomy. We administer ephedrine sulfate only where the systolic blood pressure

reading prior to administration of the analgesia is 100 mm. of mercury or less. Only on very rare occasions was it necessary to give ephedrine during the course of labor or delivery to combat a serious drop in the systolic blood pressure.

During the past two and one-half years there were 6,756 deliveries. We administered continuous caudal analgesia to 1,639 patients. Of these 1,525 had complete relief from pain during labor and delivery. Table I shows that forty patients had only partial relief from pain during labor and delivery was accomplished by supplementary inhalation anesthesia. There were also seventy-four patients who had no relief from pain at all. Both of these groups are classified as failures.

TABLE I EFFECTIVENESS OF CONTINUOUS CAUDAL ANALGESIA	
Complete relief of pain.....	1,525
Failures.....	114
Partial relief of pain.....	40
No relief of pain.....	74
Total.....	1,639

Dislodgment of the needle or inability to block the eleventh and twelfth dorsal nerves effectively accounted for most of the partial failures. In most of the latter instances there was no pain during delivery and repair; but painful uterine contractions continued during labor. A larger than usual caudal canal, defective posterior wall of the caudal canal or the presence of accessory openings on the posterior wall of the caudal canal accounts for the defective block.

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The complete failures were due to inability to enter the caudal canal because of excessive fat pad, atresia of sacral hiatus, and distortions and malformations of the bony landmarks in the sacrococcygeal area. We are also including in this group cases in which spinal fluid was obtained because of perforation of a low-lying dural sac.

TABLE II
TYPES OF DELIVERIES UNDER CONTINUOUS CAUDAL
ANALGESIA

Spontaneous.....	93
Low forceps.....	1,225
Midforceps.....	52
Manual rotation and midforceps...	103
Forceps rotation.....	19
Breech extraction.....	10
Cesarean section.....	20
Internal podalic version.....	3

Table II shows the types of deliveries in the 1,525 patients who were delivered under this form of analgesia. A high incidence of operative deliveries results from the use of any form of obstetrical analgesia. The increase, however, is limited to low forceps and "outlet" forceps. Routine use of low forceps and episiotomy on all primipara has become standard even when no analgesia is used. Similar management is advised during subsequent deliveries in order to maintain adequate pelvic floor support and prevent rectocele and even cystocele.

Mengert³ and Baptisti⁴ insist, however, that when continuous caudal analgesia is used other operative procedures are increased. These procedures are necessary because of failure of occiput-posterior positions or deep transverse arrest of the head to rotate and descend spontaneously. It is claimed that the obliteration of the bearing down reflex by the use of continuous caudal block and the marked pelvic floor relaxation prevents spontaneous rotation to the anterior position, thus necessitating intervention to effect delivery.

For a long time we have believed that the early correction of an occiput-posterior position or deep transverse arrest after full dilatation was of decided benefit to the parturient and to the fetus. Although a waiting period might be permitted it is

not necessary. With the cervix fully dilated and the head in either malposition, every forceful exertion produces pressure and traumatizes the soft tissue structures of the birth canal. These forceful "tries," particularly in such instances, may cause injury to the uteropubic fascia by stretching or lacerating its fibers or by submucosal hemorrhages, laying the groundwork for the formation of cystocele. These continued forceful exertions also cause similar damage to the parametrial tissue and the cardinal ligaments of the cervix predisposing to early descensus and beginning prolapse of the uterus. It cannot be denied, also, that intracranial hemorrhage in the fetus is frequently the direct result of permitting patients with the above mentioned malpositions to continue long in the second stage. It appears that the elimination of all these bearing down attempts and early correction of the malposition traumatizes to a minimum the soft tissue structures of the birth canal. Bill⁵ has long advocated a watchful waiting policy during the first stage of labor in occiput-posterior positions but insists that early correction and delivery after complete cervical dilatation is more beneficial to mother and infant.

Early in the onset of labor in occiput-posterior position or deep transverse arrest, the pains, although frequent, are ineffectual and mainly limited to the lumbar region. This type of ineffectual labor may continue for many hours without any appreciable progress in dilatation or descent, but nevertheless produces physical and psychic exhaustion. In these instances preliminary sedation with morphine sulfate (gr. 1/4) to span this early period of ineffective labor, is advisable. After a lapse of several hours, when a 5 or 6 cm. dilatation is reached, a tight Beck⁶ binder is applied to fix the presenting part in the pelvis and steady the fetal ovoid. The application of continuous caudal analgesia at this point gives the patient complete relief from pain during the remainder of labor. Full dilatation is reached rapidly and spontaneous corree-

tion of the malposition and descent in many instances takes place. If anterior rotation is not reached, early correction and delivery are performed.

TABLE III
MAJOR OPERATIVE DELIVERIES

	Under Caudal	Not under Caudal
Total deliveries.....	1,525	5,231
Manual rotation and midforceps.....	103	129
Forceps rotation.....	19	17
Midforceps.....	52	57
Internal podalic version.....	3	10
Percentage of major operative deliveries.....	10.9%	4%

In Table III are listed the major operative deliveries in the 1,525 patients who received continuous caudal analgesia, and in the 5,231 patients who were delivered without this form of analgesia. There were 177 such deliveries under caudal block or an incidence of 10.9 per cent. Where no continuous caudal analgesia was used the incidence of major operative deliveries was 4 per cent. This appears to be a high incidence of operative deliveries; but our policy of early interference in the second stage accounts for this more than the type of analgesia. Furthermore, the ease and safety with which these procedures can be performed under this form of analgesia dictates the policy of earlier interference.

TABLE IV
COMPLICATIONS FOLLOWING DELIVERY

	Under Caudal	Not under Caudal
Laceration of cervix.....	2	13
Duhrssens incisions.....	0	3
Retained placenta.....	2	13
Postpartum hemorrhage.....	1	9

The complications following delivery under this form of analgesia are much fewer. Table IV shows that laceration of the

cervix occurred two times and there were no instances of Duhrssens incisions. The placenta was retained on two occasions and only one case of postpartum hemorrhage was found in our entire series of 1,525 cases in which continuous caudal analgesia was used.

In the group in which no continuous caudal analgesia was used, although the operative incidence was lower, the complications were more numerous. Here we found thirteen cases of laceration of the cervix, thirteen retained placentas, nine instances of postpartum hemorrhage and three cases which needed Duhrssens incisions.

We find now, as in our preliminary report, that continuous caudal analgesia has no effect on the initiation of respiration in the newborn. Even in instances in which prolonged inhalation anesthesia is not used for the delivery and only a slight amount is given as the presenting part clears the perineum, initiation of respiration is sometimes delayed. Under continuous caudal analgesia respiration is initiated even before complete delivery is effected. As the head slips over the perineum and the anterior shoulder is being fixed under the symphysis to deliver the posterior shoulder, the infant emits a cry. There were ten stillbirths in this series. In six instances the fetal heart sounds were absent or there was doubt as to their presence before the analgesia was instituted. Maceration was found in all these instances in varying degrees. The other cases were obviously due to obstetrical traumatic deliveries, three instances of version following failure of forceps and one instance following a difficult midforceps delivery.

We encountered only the minor complications reported by Gready.⁷ Inability to enter the caudal canal due to excessive fat pad in the sacrococcygeal area caused three instances of superficial infection over that area. This was undoubtedly due to the deposit of the metycaine solution superficially, on the erroneous assumption that the needle was in the caudal canal.

There were four instances of dural puncture and clear spinal fluid was obtained. In all of these instances the administration of continuous caudal analgesia was abandoned. However, we had three other instances of inadvertent spinal anesthesia despite the fact that after a short waiting period following the introduction of the needle into the caudal canal no spinal fluid was obtained. The symptoms of spinal anesthesia were recognized soon after the administration of the first 8 cc. of anesthetic fluid. In each instance it was recognized by rapid cessation of all pain, rapid advance of the level of anesthesia above the umbilicus, loss of muscular tone of the lower extremities and very early rectal sphincter relaxation. It is important to be aware of these signs early, lest the subsequent fractional doses be administered and produce serious massive spinal anesthesia. When these signs were noted and adequately appraised, the needle was withdrawn. In each instance the patient had enough anesthesia for labor and delivery.

We also met with high level caudal analgesia in four instances. This developed despite slow administration of the solution and only when indicated, i.e., when pains returned and the level of anesthesia was much below the umbilicus. In these instances the introduction of the usual 20 cc. of 1.5 per cent metycaine, although properly spaced, caused the patient to become suddenly restless, anxious and with visible shaking of the upper extremities and trunk. They complained of precordial pressure and dizziness. The anesthetic level reached up to the neck. Such instances are explained by small epidural and narrow lateral dural spaces which permit the fluid to diffuse rapidly upward. These were easily combatted by elevation of the head and trunk to permit downward gravitation of the anesthetic fluid. The patient was assured and comforted and in a matter of minutes the symptoms disappeared and labor was permitted to continue. Delivery and subsequent course were uneventful. Subsequent

injections, when they became necessary, were reduced to 10 cc. at each dose.

There were no instances of nerve injury, bone injury, inadvertent intravenous injection, broken needle or false passage of the needle. Where the analgesia was used for a period longer than six or eight hours there was postpartum urinary retention and loss of rectal sphincter control. These symptoms were temporary and they disappeared early in the postpartum period.

We had one maternal death in a patient who received continuous caudal analgesia for labor and delivery; but it did not appear that death was due to the analgesia.

CASE REPORT

F. W., thirty-five years old, para 1, gravida 11, had a difficult delivery by Dührssen's incisions of the cervix and midforceps three years previously. She had, however, a normal puerperium and no subsequent pelvic complaints. She was admitted in mild labor, and after several hours her pains became regular, strong, occurring every three to five minutes. When she reached five cm., dilatation and the head was at the spines, continuous caudal analgesia was administered. Cervical dilatation was slow, and after four hours she was only 9 cm. dilated and the head was 1 cm. below the spines. During the entire time the anesthetic fluid was administered in 20 cc. doses only when the level fell below the umbilicus and pains became perceptible. This occurred at about forty-five minute intervals.

Full dilatation was reached two hours later and at that time the head was 2 cm. below the spines. At this time the level of the anesthesia was tested and found to be below the umbilicus. She complained of slight pain over the right side immediately above the symphysis. She was given the last dose of 20 cc. of 1.5 per cent metycaine, the needle was removed and the patient was made ready for transfer to the delivery room. During the six hours of the administration she had no complaints.

When she was placed on the delivery table she became cyanotic, restless, complained of dizziness and involuntarily removed her legs from the stirrups. Inhalation of oxygen eliminated the cyanosis and delivery of a living male infant by outlet forceps and episiotomy was

easily accomplished. The placenta was expressed intact five minutes later and the episiotomy was repaired. During this time the patient had several more attacks of cyanosis and restlessness, but oxygen inhalation successfully combatted them. Shortly after the delivery she became markedly cyanotic. The pulse was slow, of fair quality and regular. The blood pressure could not be obtained. Despite continued oxygen administration, coramine and adrenalin medication and artificial respiration she expired about forty minutes after the first of the symptoms appeared.

Consent for postmortem examination could not be obtained. Blood and spinal fluid specimens, however, were obtained a few minutes after death and were sent to the Eli Lilly Laboratories⁸ for detection of presence of metycaine. No metycaine was found in either specimen. The total amount of metycaine used (1.5 per cent) was 150 cc. over a period of almost seven hours.

The absence of metycaine in the spinal fluid excluded death due to massive spinal anesthesia. Similarly, the absence of metycaine in the blood eliminated metycaine intoxication as a cause of death. It appears, from the clinical picture, that death might have been due to pulmonary embolism. A similar complication has been reported by Diddle and Hill.⁹ Complete postmortem examination of their case revealed the unusual source of the embolus to be the extradural venous plexus of the sacral spinal canal. The use of a No. 15 G. needle to enter the caudal canal might well cause sufficient trauma for complications. Other sources of pulmonary embolism are possible in obstetric patients.

SUMMARY*

1. Continuous caudal analgesia was attempted in 1,639 obstetric patients. Complete relief from pain was obtained in 1,525

patients. Forty patients had only partial relief from pain while seventy-four had no relief. Anatomical malformation was the main reason for the partial and complete failures.

2. Early correction of occiput-posterior position and deep transverse arrest account for the increase in major operative deliveries and not the analgesic method used. Such early correction prevents soft tissue trauma, prevents pelvic relaxations and displacements and intracranial damage in the fetus.

3. There was a higher percentage of major operative deliveries when continuous caudal analgesia was used. The complications during and following delivery, however, were much fewer than those found in the cases in which the major operative procedures were done with other forms of anesthesia.

4. There is no delay in initiation of fetal respiration. Fetal distress is very rare. Ten stillbirths occurred; six were suspected before the analgesia was started and were confirmed by presence of maceration. Four stillbirths were due to obstetrical trauma.

5. Some of the minor complications to the mother have been noted and discussed. There was one maternal death which occurred after delivery and after six hours of uneventful continuous caudal analgesia. It is doubtful that this method of analgesia was the cause of this death.

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* Since this article was submitted for publication we administered continuous caudal analgesia to over 700 more patients. The results and conclusions are substantially the same as described above.

TRAUMATIC PALMAR ANEURYSM

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THE advent of World War II has brought into increasing prominence the subject of traumatic arterial aneurysm, and the frequency with which one encounters articles on this topic in the surgical literature attests to the growing importance of traumatic vascular lesions. Matas' review⁶ of blood vessel injuries in World War I revealed the fact that aneurysm occurred in 1 per cent of all wounds of the extremities, a figure that included both arteriovenous and arterial types. The incidence, therefore, of both true or pseudo-arterial aneurysms must have been smaller. Although it is too early for the compilation of any reliable statistics for World War II, one can be quite sure that as a result of the better trained surgeons available in forward areas in this war, death from hemorrhage resulting from vascular injury has decreased, and traumatic aneurysm, the sequela of such injury, has increased.

In general, aneurysm of peripheral vessels may be divided into two main groups:^{12,13}

- I. Arterial
 - (a) Acquired
 - (1) Result of trauma
 - (2) Result of degenerative disease
 - (b) Congenital
- II. Arteriovenous
 - (a) Acquired
 - (1) Result of trauma
 - (2) Result of degenerative disease
 - (b) Congenital

In this paper, we shall limit ourselves to a discussion of traumatic arterial aneurysms of the palmar vessels, and where indicated, interpolate some observations on acquired arterial aneurysms in general. As a group, the traumatic arterial type of aneurysm may be subdivided into two categories, both of which are characterized

by damage to the vessel wall resultant from some form of trauma. The true form is distinguished by a weakened arterial wall which is pushed ahead by the dilatation, producing a sac which has a neck through which it communicates with the main vessel and whose contents are liquid and coagulated blood in various stages of resolution. In the false variety or pulsating hematoma there is a destruction of the vessel wall with an ensuing spillage of varying quantities of blood, the formation of a hematoma which may or may not be well demarcated by the surrounding tissue, and which may burrow into soft structures or dissect along fascial planes. Once the active spread of blood has stopped, a process of absorption, organization, and the proliferation of fibroconnective tissue elements sets in, with the formation of a retaining sac. As this process continues, the sac eventually becomes lined with an endothelium similar to that of the injured vessel while its wall assumes a tough elastic quality. A multiplicity of aneurysmal shapes results, the end-product depending on the character of the surrounding structures and the varying degree of resistance they present to the developing tumefaction. The time required for the development of such a sac is variable, but an extravascular hematoma may become organized into a fibrous aneurysm in six weeks. From this description, it can be seen that the differentiation between a false and a true aneurysm can be made on the absence or presence of muscle elements in the wall of the aneurysmal sac.

A survey of the literature on traumatic palmar aneurysm reveals the interesting fact that the incidence of this lesion is considerably less than might be expected. When one considers how richly vascularized is the palm of the hand, and how

frequently exposed it is to trauma of all sorts, one would expect the palm to be a most likely site for the development of traumatic aneurysms. And yet the reverse is true, for such lesions are comparatively rare. Middleton's review¹ provided seventy recorded cases up to 1933, fifty-four of which were false and sixteen true aneurysms. The false aneurysms resulted from puncture wounds of the hand with one exception, that in which the aneurysm followed subcutaneous rupture of an artery during the reduction of a metacarpophalangeal dislocation. The true aneurysms, representing the localized ectasia of one of the palmar vessels, were relatively rare occurrences and the majority of such cases were traumatic in origin. A single case³ was recorded in which the arterial affection associated with subacute bacterial endocarditis was considered to have followed blocking of the vessel by an embolus. Where no obvious cause could be assigned, the palmar aneurysms were deemed spontaneous, and of this variety only two cases were found, one⁴ that of an ulnar artery aneurysm in a young woman, and one⁵ in which the lesion was not palmar but occurred on the dorsum of the hand. Of traumatic aneurysms not resulting from an open wound there were fourteen cases divided into two classes: (1) Acute and due to a single definite contusion, and (2) more delayed and gradual, the result of repeated minor injury.

Of the six cases of the delayed type due to prolonged frequently recurring minor trauma, the injury was incidental to the individual's work and could best be designated as occupational aneurysm. The remainder belonged to the acute form, the result of striking a single sharp blow with the palm of the hand. The time required for the development of these aneurysms ranged from three weeks to five months. To this series Middleton contributed two cases of his own of the occupational variety, one of the ulnar artery in the vicinity of the hamate bone and one of the

superficial volar branch of the radial artery. Since Middleton's review several cases have appeared sporadically in the literature, namely, that of Brechot and Reinhold,⁷ one by Wapshaw⁸ following a midpalmar laceration and developing in twenty-one days to a plum-sized mass, one by Robb, McKetchnie and Guthrie⁹ following palmar puncture by glass, a case by McLaughlin,¹⁰ as well as two ulnar and one superficial arch aneurysms reported by Pemberton and Black.¹¹

The signs and symptoms of traumatic palmar aneurysms are essentially the same as aneurysms in other regions. However, it must be borne in mind that small, deep-seated lesions may fail to give any of the classical signs and symptoms. One must also remember that with an arterial aneurysm the effects are less complex and confined to the area supplied by the injured artery, whereas an arteriovenous fistula may produce profound effects on the entire circulatory system.¹⁵

The findings in aneurysm may be briefly mentioned as follows: (1) An expansile pulsating tumor along the course of a vessel; (2) a scar of the preceding injury in the false type of aneurysm; (3) a variable amount of pain depending on the structures compressed by the tumor; (4) an absent or weak pulse distal to the aneurysm with corresponding oscillometric and blood pressure readings; (5) a possible bruit heard over the mass; (6) a possible thrill felt over the mass; and (7) a varying degree of interference with the arterial supply of the part, venous stasis with edema, claudication and ischemic neuritis.

The signs and symptoms enumerated above will aid materially in the diagnosis of the condition. In addition, there are several procedures which may be of considerable aid in both the diagnosis and the treatment: (1) *Compression* proximal to the aneurysm may allay or abolish the pulsation. (2) *Aspiration* with a fine needle of those masses which are suspicious and do not present the classical signs and symptoms. This is most applicable to

small deep-seated aneurysms in which overlying structures may mask the nature of the lesion. It is most embarrassing to



FIG. 1. Showing extent of palmar aneurysm.

the surgeon to incise into an aneurysmal mass when it is not expected. (3) *Arteriography*. This is not only an aid to diagnosis but a valuable adjunct in estimating the size and shape of the mass as well as a means of evaluating the possible technical difficulties to be encountered and the circulation to be excluded by the contemplated operative procedure. (4) Branham's bradycardic reaction, the presence of pulsating veins, and the determination of carbon-dioxide and oxygen contents of veins may serve to differentiate between arteriovenous and arterial aneurysms.

The radical cure of aneurysm elsewhere than in the palm of the hand often requires the interruption of the main arterial supply of the part. In such cases a careful evaluation of the collateral circulation is a pre-requisite before operation can be undertaken. For this, the Moszkowicz-Matas hyperemic test or one of its modifications¹⁴ may be employed, and if there is need for it, the capacity of the secondary channels may be augmented by prolonged intermittent compression of the artery proximal to the aneurysm by means of bands and by reducing the peripheral resistance to the blood flow by means of sympathectomy, a procedure which will

enhance the collateral circulation as well as prevent immediate postoperative vasospasm.¹⁶ In the case of palmar aneurysm, however, the vascularity of the part is so great that little apprehension need be felt regarding the adequacy of the circulation after the operative procedure, and methods designed to either test or increase the capacity of secondary channels may be dispensed with. Opposed to the general consensus that surgical intervention be delayed to permit improvement in circulation, Bullock¹⁷ contends that inasmuch as traumatic aneurysm is a clot with a cavity in it, lined by endothelium and connected with a blood vessel, the essential thing is to discover it as early as possible and not wait until the aneurysm develops. Thus, maintains Bullock, many aneurysms can be prevented by early attention to symptoms that are the results of injuries to vessels and by immediate repair. In the case of infected wounds it is advisable to wait for the disappearance of bacteria from the adjacent tissues¹⁸ unless complications arise which demand earlier intervention. Among the most likely developments necessitating earlier surgery are increase in size of the aneurysm causing compression of collateral channels or adjacent nerves, secondary hemorrhage, and injuries to important nerves at the time of the arterial injury.

The goal of all treatment of traumatic aneurysm is its cure with a minimum of disturbance to the blood supply of the tissues beyond the lesion. This is especially significant when one realizes that, in contradistinction to spontaneous aneurysm of degenerative vascular disease which occurs in more elderly individuals, traumatic aneurysm is more prone to occur in young active individuals whose future usefulness will depend on the maintenance of a normal blood supply.

The surgical procedures employed may be briefly enumerated as follows: (1) Excision of the aneurysm with arterial anastomosis; this will depend on the defect to be bridged; (2) obliterative endoaneurysmorrhaphy with or without proximal

and distal ligation; (3) proximal and distal ligation of the vessel with excision of the aneurysmal sac; (4) restorative endoaneu-

turned to his army post and reported at sick-call because of a lump which he noticed at the site of the previous injury. A diagnosis

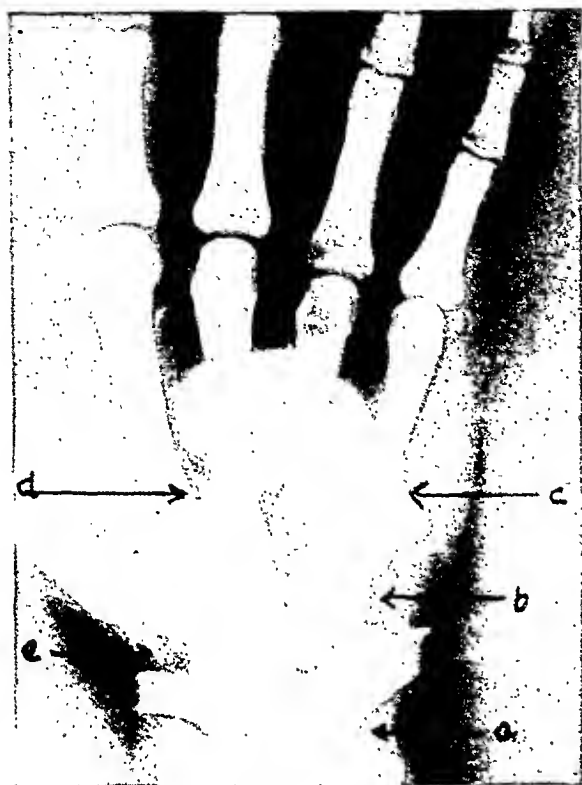


FIG. 2. Arteriogram: a, terminal ulnar artery; b, fusiform dilatation; c, main sac; d, superficial volar arch; e, radial artery.

rysmorrhaphy; (5) proximal ligation; and (6) proximal clamping.

CASE REPORT

The case we are presenting here has a two-fold interest; it falls into that rare category of true acute traumatic palmar aneurysms and exhibits an extremely short time interval for the full development of an aneurysmal sac.

L. S., an eighteen year old soldier, while a passenger in an automobile, was involved in an accident when the car struck a wall on June 18, 1945. The force of the collision threw the soldier against the dashboard of the car causing him to strike the palm of his left hand sharply against a metal protuberance. There was no laceration of the hand and no other injuries except a small scalp laceration. He was taken to a civilian hospital where first-aid treatment was given, following which he returned home. One week later the soldier re-

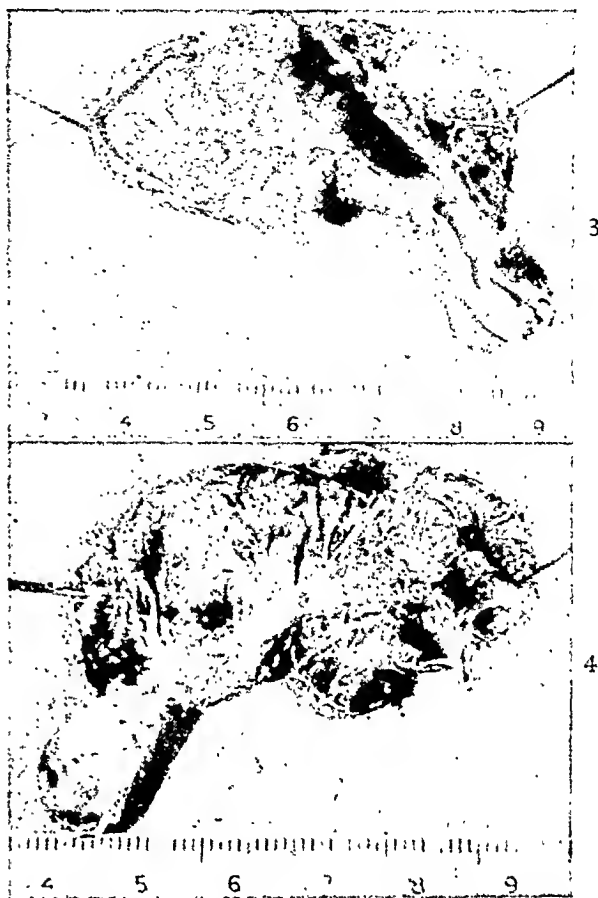


FIG. 3. Anterior view of specimen; compare with arteriogram.

FIG. 4. Posterior view of specimen.

of cyst was made and an aspirating needle was inserted into the mass. Fresh blood was removed from the tumefaction. The patient was then sent to the hospital.

Examination on June 26th showed a well nourished, white, young male whose only lesions were a small laceration of the scalp and a large palmar mass. Occupying the medial aspect of the left palm from the wrist to the mid-palm was a pulsating tumor 7.5 cm. by 2.5 cm., expansile, with some ecchymotic spots over its proximal portion. (Fig. 1.) There was no bruit and no thrill. The mass could be emptied by pressure but promptly refilled. The pulsation could be stopped by compression of the ulnar artery at the wrist. Compression of the radial artery produced no change. There was some numbness and diminished sensitivity of the lateral aspect of the little finger and medial side of the ring finger. The blood pressure of the right arm was 116/60 and of the

left arm 114/60. A diagnosis of terminal ulnar and superficial arch aneurysm was made. An arteriogram (Fig. 2) was done to outline the extent of the aneurysmal sac and determine its vascular connections. Under pentothal anesthesia, a small incision was made over the terminal ulnar artery where a small fusiform sacculatation was found just distal to the hook of the hamate bone. Ligation of the artery proximal to the dilatation failed to stop the pulsation of the mass. The dissection was continued after enlarging the skin incision into the palm of the hand where a large sac was found continuous with the fusiform sacculatation and involving the first portion of the superficial volar arch. The mass was excised with the sacrifice of a minimum amount of the arch.

The pathologist's report on the mass (Figs. 3 and 4) is as follows: The specimen consists of a 1.5 cm. arterial segment, the terminal end of which balloons out into a sac which has a thin wall 1 mm. in thickness. The sac-like portion is 4.5 cm. by 2 cm. by 0.5 cm. Microscopic sections show a stripped and roughened intima with subintimal hyaline degeneration and an edematous muscularis. Acute inflammatory and hemorrhagic foci are scattered in the arterial wall. Diagnosis: (1) Aneurysm-traumatic, (2) arteritis, intramural, acute.

SUMMARY

1. A case of true acute traumatic aneurysm of the palm is presented.

2. The literature on traumatic palmar aneurysm is reviewed and some observations on traumatic aneurysm are made.

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INSPISSATED BLOOD AND THE GROWTH OF FIBROMATOUS UTERINE TUMORS*

PRELIMINARY REPORT

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AT the Southern Sectional Meeting of the American Federation for Clinical Research the author presented his theory of positive chemotropism.¹ This thesis endeavored to explain the origin and growth of fibrous neoplasms by the fact that inspissated blood serum possesses the property of attracting fibroblasts which finally produce these tumors.

To prove this theory, the author described two sets of experiments: The first employed blood serum taken from a "Wassermann-fast" case. Although this particular blood serum was three years old, it produced a small fibromatous tumor on the author's right thigh after this material had been injected intradermally repeatedly. The control site, on the opposite thigh, which received similar injections of saline, remained negative.

The second investigation employed blood serum from the author, and this serum was injected intradermally repeatedly just above the previous experimental site on the author's right thigh. The control site, on the left thigh, which received similar amounts of saline, remained negative.

It was found, upon thorough histological examinations, that the site which was injected with the author's serum, developed a larger fibromatous area than did the area which received the three-year old serum taken from the luetic case.

These histopathological changes demonstrated that these serum injections produced subepithelial changes very similar to those seen in keloids.

In another recent paper, Marshall² showed that the tumor section of tissue treated with his serum was twice as dense as the control tissue. This new technic, to determine the ratio of density in tissues, was accomplished with the use of a photographic light exposure meter. This method seems much simpler when compared with the older methods of determining tissue density such as the study of the velocity of fibroplasia or the determination of the tensile strength of tissues.

The purpose of the present study is to carry this tumor study further in order to determine whether or not this same pathological explanation might be applied to the pathogenesis of uterine fibromyomas, commonly termed "uterine fibroids."

ETIOLOGY OF UTERINE FIBROID TUMORS

The etiology of these tumors still remains to be answered fully. Goodwin,³ among others, has stated that these neoplasms are found most frequently in women between thirty and forty who have not borne children. He stated that old-maid school teachers were particularly susceptible, and that negroes were more susceptible than whites (as is the case with keloids and

* Read before the Eastern Section of the American Federation for Clinical Research at the Philadelphia General Hospital, December 8, 1945. The authors are most grateful to Judy, and to her puppy, Ginger, for their cooperation. The writers thank Professor Andrew C. Ivy, of Northwestern University Medical School, for his suggestions and encouragement of this research. Dr. Samuel Rosenthal, of Marquette University Medical School examined and presented his reports of the pathological specimens, and the authors are indebted to him for his valuable cooperation.

hypertrophic scars). Recently, many investigators have discussed the relationship which is thought to exist between hyperactivity of ovarian secretion and fibroid formation. Some workers think that in undeveloped uteri, certain groups of uterine muscles are activated by the effects from the ovarian hormones and that muscle cells proliferate and become fibroid nodules, especially in areas where the circulation is impaired temporarily. Goodwin observed that fibroids grow only during the menstrual life and remain stationary or atrophy after the menopause.

Kakuschkin⁴ thought that these tumors were a pathological reaction to an intensified ovarian stimulation replacing the normal physiological reaction of pregnancy. He reasoned that when pregnancy did not occur, the irritative power of the follicle continued and the regulatory function of the corpus luteum and fetus were absent. Hence, the potential energy of muscular elements of the uterus were manifested abnormally. In other words, Kakuschkin believed that a uterine myoma was the menstrual product of a sterile woman with a high reproductive potency.

Baker⁵ called attention to the possibility that endometrial hyperplasia, uterine fibroids, and endometriomas may have a common background. The fundamental cause may be the action of the follicular hormone which acts on the endometrium, the myometrium and the ectopic locations from which the endometrium arises. This follicular action, according to Baker, acts upon the genital tract as a whole. He wrote that the removal of both ovaries results in involution of the uterus, and he believed that a definite relationship exists between ovarian function and the presence of a fibromyoma in the uterus, in the sense that hemorrhages in a fibromyomatous uterus depend upon functional alterations of the ovaries, and vice versa, that the presence of a fibromyoma in the uterus causes alterations in the ovaries. He thought the cause for these uterine tumors may be attributed to some irregularity

of function of the anterior pituitary and ovarian hormones which regulate the growth and function of all the pelvic organs. Hence, if this stimulation is sufficiently prolonged, uterine fibroids may be produced, as well as an overgrowth of the uterine endometrium. This viewpoint has been described also by Witherspoon,⁶ who found a 10 per cent incidence of salpingitis associated with fibroids in the cases he observed in negro women.

In another paper, Witherspoon⁷ mentioned a theory attributed to Sampson. This theory is unique because it suggests a clue to the etiology of uterine fibroids which seems to have been overlooked. Sampson thought that local hyperplasia of uterine muscle cells was caused by the stimulus of menstrual blood which had acquired access to the myometrium by retrograde flow through the venous sinuses of the endometrium. However, no mention was made as to just how this blood produced uterine fibroids. Nor has Sampson's theory been given much credence or prominence in recent writings on this topic.

Goodwin⁸ wrote that "cardiac and cardio-vascular changes are frequently associated with fibroids in women, especially if bleeding has been a prominent symptom or if there are extensive degenerations in large tumors. Older pathologists and clinicians held that the factors which produced these changes must be identical with those which caused the tumor, and that a woman with fibroids might be expected to develop cardio-vascular changes sooner or later; this they termed 'fibroid heart.' This theory has never been completely accepted."

These uterine fibromyomas, or fibroids, occur most usually in the interstitial form, according to Boyd.⁹ This type of tumor is supplied with blood from the surrounding muscle so that degeneration is rather uncommon. Obviously, these fibromyomas of the uterine fundus have more space in which to grow, once they are formed, in contrast with cervical fibromyomas, which

are relatively uncommon. In the authors' opinion, this may be due to the fact that the cervical tissue is denser and the blood supply is not so marked.

If we remember that these uterine tumors occur only during the reproductive period, we can recognize a correlation with the menstrual mechanism. Sampson's theory, that the local hyperplasia of uterine muscle cells is caused by the stimulus of menstrual blood through a retrograde flow through the venous sinuses, deserves much more attention than it has been given. However, this viewpoint does not explain the origin of the tumor nor its exact pathogenesis.

Furthermore, one should remember that fibroids are found more frequently in colored women. This is true also for the formation of keloids which occur far more frequently in the colored race. In our opinion, the pathogenesis has a similar origin. This is based on the presence of inspissated blood which is forced into the tissue stroma by means of the loss of, or damage to, the endometrium. This may be due to chronic infection, for Witherspoon and Butler¹⁰ found that the negro presented pelvic infections in 100 per cent of the cases which they studied. This infection was not so marked in the white women who were studied, and neither was the incidence of fibroids as marked as it was in the colored race.

The tendency for hemorrhage, either by diapedesis or rhexis, into the uterine fundic stroma, is certainly enhanced by means of the uterine contractions which occur before and during the menstrual periods. These uterine contractions may prove to be an important factor in that they may force the blood deeper into the tissue stroma. Once this blood becomes inspissated, there is cause to believe that it may be the main etiological agent in the formation of these fibromyomas. For inspissated blood serum has been shown by Marshall to possess the ability of attracting fibroblasts to the traumatized area. When the fibroblasts begin to grow, the

formation of a fibroid may become a certainty.

Boyd¹¹ aptly summarizes it this way: "A tumor or neoplasm may be defined as a growth of new cells which proliferate without control and which serve no useful function—the difference between neoplastic and inflammatory conditions is usually easy. In inflammation the causal organisms can be demonstrated, the inflammatory cells which may constitute a lump or mass are varied and pleomorphic, and in the course of time the lesions clear up. In a true neoplasm the cells are usually of the same type (epithelial cells, fibroblasts, etc.) and the condition is progressive. But the matter is not quite so simple. The cells of a tumor may be very pleomorphic (osteogenic sarcoma, glioblastoma multiforme), and on the other hand a chronic inflammatory condition may show marked cellular proliferation as in the hyperplastic form of tuberculosis. Repair, indeed, is just proliferation, and it may be hard to say where the proliferation of repair ends and the proliferation of neoplasia begins. These considerations have a two-fold importance. In the first place they suggest that it may be unwise to draw too strict a line between proliferation and neoplasia, so that there may be borderland conditions such as Hodgkin's disease which partake of the character of both. In the second place, it is possible that the hyperplasia of the chronic inflammation may cross the line and become hyperplasia of tumor growth."

Ewing, according to Moore,¹² has called attention to the close association of small myomas with blood vessels. Ewing observed anomalies and heterotopic tissue in uteri with myomas; hence, he suggested that an anomaly in the formation of blood vessels was a causative factor for the production of these myomas. According to Marshall's theory of positive chemotropism, the diapedesis from injured blood vessels produces an active attraction of fibroblasts to the inspissated blood. When these builders of either repair or tumors arrive in the injured area, an overproduc-

tion of repair tissue may produce the so-called uterine fibroid.

There is a striking clinical correlation which we wish to report. We all are acquainted with the classical experiments which employed estrogenic hormones placed in tablet form under the skin of guinea-pigs. Apparently this procedure produced uterine fibromyomas in these animals.¹³ These tumors ceased to grow and retrogressed when the hormone ceased to act. The correlation is that humans, treated with estrogenic hormones, have developed acne vulgaris (Hamilton).

In the case of guinea pigs, an increased blood supply to the uteri may have produced minute hemorrhages which would, as we have mentioned, attract fibroblasts, which in turn would produce fibroids. When acne in humans was produced through the use of the estrogenic substance, an increased blood supply to the skin could have been observed, as it is in most cases of acne. Here again, inspissated serum can attract fibroblasts with the result that the patients may develop hypertrophic scars or keloids. This correlation becomes all the more striking when we remember that hypertrophic scars and keloids are not too far removed pathologically from uterine fibromas.

A review of the literature on this subject would not be representative unless the work of the Englishman, Robert Bell,¹⁴ were mentioned. Bell thought that uterine fibroids and also mammary adenomas were caused by bleeding from the tissue capillaries. This effusion of blood in diseased tissue (for Bell was of the opinion that such a uterus also exhibited metritis) caused a blood clot which formed a vascular connection with its environment and began to grow after the blood clot became organized. Thus the uterine fibroid came into being, according to Bell.

This last reference, is of particular interest to the authors, since Bell recognized the fact that infection and the marked blood supply of the uterus predisposed it to hemorrhage. Our theory

differs with his in that he thought that the organized blood clot actually formed the uterine fibroid, while our opinion has it that this inspissated blood attracts the fibroblasts which begin to lay down an overabundance of fibroblastic repair tissue, and this forms the uterine fibroid.

In our haste to formulate theories, which we think are promising, we tend to overlook the concise and logical thinking of our predecessors, men who accomplished so much with so little scientific equipment with which to work. It was the great Englishman, Abernathy (1825)¹⁵ who wrote: "If, then, the coagulable part of the blood be from any cause effused, if the adjacent absorbents do not remove it, and the surrounding vessels grow into it, the origin of a tumor may be thus formed. It may be right to repeat a little on the causes which may occasion a deposition and consequent organization of the coagulable part of the blood; as such reflections throw light on the nature and growth of tumors, and lead to the establishment of principles, which are applicable to tumors in general. The deposition of the coagulable part of the blood may be the effect of accident, or of a common inflammatory process, or it may be the consequence of some diseased action of the surrounding vessels which may influence the organization and growth of tumors."

AUTHORS' PRELIMINARY EXPERIMENT ON DOG

On September 18, 1945, a six months old dog was prepared surgically and was given nembutal anesthesia. The abdomen was opened routinely and the left horn of the uterus was injected with saline solution. The right horn of the uterus was to be injected with whole blood from the dog. Fine hypodermic needles were employed for both injections, and it was not a certainty that we succeeded in injecting the dog's blood into the right horn. The dog's horns were about 2 mm. in diameter, and extreme care was taken not to injure

these tissues. The abdomen was closed routinely, and the puppy was returned home after ten days. A few days later, the dog began to cough and grind her teeth, and she was returned to the hospital where a diagnosis of pneumonia and encephalitis (probably due to a virus) was made. She made an uneventful recovery except that she showed athetoid movements, such as snapping her jaws and puffing her cheeks. These were especially evident whenever she became excited.

Both uterine horns were removed on November 21, 1945, under nembutal and magnesium sulfate anesthesia. These tissues were placed in separate labelled vials, which contained 10 per cent formalin, and these were sent to Dr. Rosenthal for microscopic examinations. Gross examination of tissues revealed that no changes were evident in either horn.

COMMENT

We do not believe that we made a satisfactory injection of whole blood into the uterine horn, since we experienced much difficulty with obtaining blood from the vein for the injection and the blood may have coagulated. Extreme care, in injecting these horns was exercised, since these tissues were very delicate and thin.

We are now making arrangements to repeat this procedure on an older dog. We plan to use an animal who has whelped at least one litter of puppies, since the uterine horns of such an animal are larger and thicker. This, of course, will render these tissues easier to inject with saline and also whole blood.

If this procedure can be accomplished satisfactorily, we believe that we have a much better chance to develop a uterine fibroid in the dog's horn from the injected blood. Should this come about, we will have definite data as to the formation of uterine fibroids, and the pathogenesis could be explained readily by the theory of positive chemotropism.

SUMMARY

In this communication, we have reviewed Marshall's theory of active chemotropism which, we believe, offers a rational explanation for the process of fibromatosis. We have reviewed these experiments in which he succeeded in producing two fibromatous lesions on his thighs. Sections of the tumors were verified pathologically by an independent pathologist.

Attention has been called to the rôle of inspissated blood as an important etiological factor which attracts fibroblasts to the injured area. An overproduction of fibroblastic tissue produces the overgrowth of this tissue or, in other words, a tumor.

Our present concept, then, as to the etiology of uterine fibroids, is that infection of this tissue predisposes to hemorrhage, which is intensified by the presence of menstrual blood during the monthly periods. The contraction of the uterus tends to drive this blood deeper into the tissue stroma.

If this inspissated blood remains for a certain length of time, a chemotropic response occurs which attracts fibroblasts to this area of injury. The "piling up" of fibroblasts, or fibroplasia, produces the uterine fibroid. If the same phenomenon occurs in other parts of the uterus, the growths may become multiple and may be expected to occur wherever the uterine blood pools have become inspissated. Obviously, the tendency for this chain of events is lessened markedly if the patient does not menstruate for one reason or another. If infection is absent, the chance for hemorrhage is lessened also.

We have reviewed the views of other investigators in relation to the production of uterine fibroids. We believe that the theory of positive chemotropism may be shown to play a major part in the etiology of such tumors, and may be demonstrated at a later time through the experiment which we have described.

We have described our first attempt to produce a uterine tumor in a female

puppy with the use of Marshall's technic. Our present failure is thought to be due to the fact that serious difficulty was met when the whole blood was inadequately introduced into the extremely delicate uterine horn.

We have described our current research attempts with the hope that other investigators, who have access to limitless material and equipment, will run their series of experiments independently to determine their own findings with our method for the production of fibromatosis in the uterus of dogs or other suitable animals.

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VARICOSITIES OF THE LOWER EXTREMITY

DESCRIPTION OF AN IMPROVED METHOD OF TESTING FOR INCOMPETENT COMMUNICATING VEINS

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THE subject of varicose veins has been clouded by a great deal of conflicting opinion as to proper treatment and by the introduction of tests which fall short of their acclaimed value. One school of thought leans toward over-simplification of the problem while another will produce chaos by applying every test, whether it is applicable or not, to each case. This is a reflection on our proper understanding of basic anatomical and physiological considerations. For purposes of clarity it is convenient to eliminate the names which have been applied to various tests and to state in basic terms the fundamental anatomic considerations and a basic method of discovering what disturbance of physiology is present in the case under study.

The basic considerations may be stated simply:

1. Do the varicosities involve the greater or lesser saphenous system? If they involve the greater system, testing will be carried out from the groin to the ankle. If they involve the lesser system, testing will be carried out from the popliteal space to the ankle. If both systems are involved, the testing must be separated for each system.

2. Are the valves in the superficial veins incompetent? The value of discovering this abnormality has been grossly overrated. It may be accepted as firm fact, based on elementary physics, that if a vein is dilated, its valves are incompetent. This is so because any valve system designed originally to take care of back flow in a normal-sized vein will fall short of its job, either wholly or in part, when that vein increases its caliber. Whether or not the incompetency of the valves in any system of veins can be demonstrated clinically, the incompetency

had best be considered as present when the veins are varicose.

3. Is the deep circulation patent? After application of a tourniquet at the point of

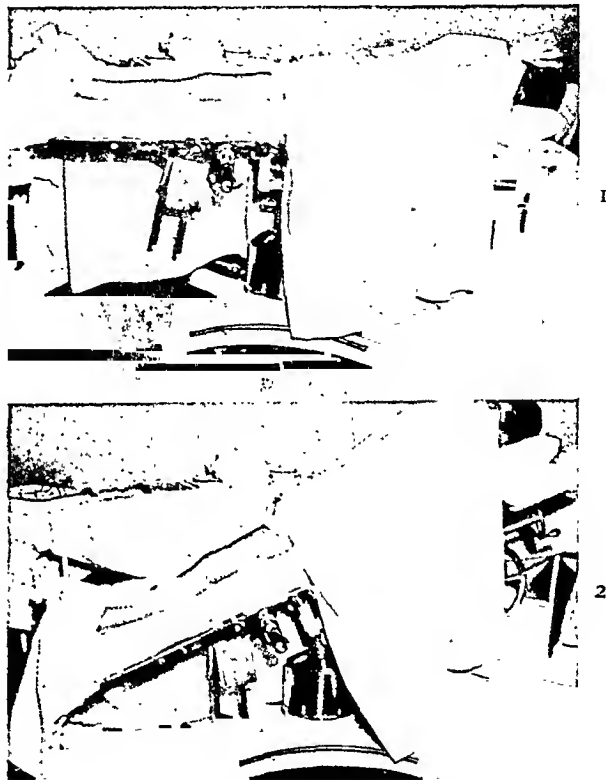


FIG. 1. Demonstrates full leg exposure and draping with foot board in place on the table. The latter will allow for tilting of the table and assumption of a near erect position.

FIG. 2. Table tilted toward erect position which allows for execution of clinical tests for venous pathological conditions.

entrance of the main saphenous trunks into the deep circulation (upper thigh for great saphenous and just below the knee for lesser saphenous) with the veins distended the patient is allowed to walk a few steps. If the veins become less tense, the deep circulation is patent. The application of a tight ACE bandage followed by walking some distance as a test for patency of the



FIG. 3. Tourniquets and bandage are in place for determination of sights of perforators by conventional methods. The patient can be placed in the Trendelenburg position before application of tourniquets or bandage.



FIG. 4.

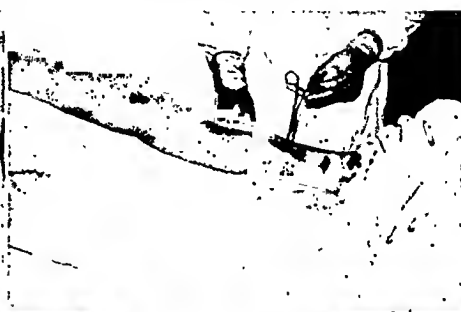


FIG. 5.



FIG. 6.



FIG. 7.

FIG. 4. Demonstrates distention of veins when patient is put in the reverse Trendelenburg position. At the point marked "X" a large perforation is almost invariably found.

FIG. 5. Improved technic for determination of exit of incompetent perforators. The tourniquet is advanced from below upward on the lower extremity. At the points where perforators are suspected, the vein is exposed and severed between clamps. The perforator, if it is found, is treated in the same manner. Preliminary testing may be carried out by the application of two tourniquets at short distances from each other while the Trendelenburg position is assumed, followed by assumption of the reverse Trendelenburg position. However, it is believed that the ligation as illustrated acts in a more effective manner than the lower tourniquet in stopping confusing flow from the distal points of the vein. The clamp is pointing to a spot of dilatation in the vein where a perforator is suspected.

FIG. 6. Demonstrates the incompetent perforator found at the point determined in Figure 5 at the point of the clamp. The trunk of the internal saphenous system has been clamped. The perforator can be seen entering the fascia of the leg and the saphenous trunk.

FIG. 7. Illustrates points at which the saphenous trunk has been exposed. At all of these points the presence of perforators was suspected.

deep circulation is based on subjective manifestations and is liable to fallacious interpretation. Venographic study is only occasionally necessary in these cases.

4. Are the communicating veins or "perforators" incompetent and, if so, where are they located? Recently great and proper emphasis has been placed on this feature of the pathology of varicosities. Several tests have appeared in the literature for determining the location of these abnormal communicating veins. Anyone who will subject these tests to careful analysis will realize that they are not altogether accurate. We discovered early in the use of these tests (with ACE bandage removed from below upward and with serial application of two tourniquets) that we were able to detect areas of bulging distal to the ACE bandage or between the two tourniquets, but that upon exposing the vein by incision over these points the perforator was not always there. We had merely discovered the point of maximum dilatation of the vein, subject to filling from the perforator, in the area between the two tourniquets. It might be found at a point some distance, medial or lateral, from the area of filling determined preoperatively. We believed that it was essential to develop some method by which perforators might be discovered as the operation progressed in order to overcome the shortcomings of tests for perforators carried out preoperatively. The method of employing vein strippers for the location of perforators leads to improper conclusions, particularly when used below the knee. Lateral branches as well as perforators will obstruct the passage of the stripper loop. The method of performing the necessary calisthenics for testing is described in the legends to the illustrations. We believe that this method is a valuable aid to this important phase of the operative treatment of varicose veins.

It is to be emphasized that the extreme reverse Trendelenburg position should be assumed and maintained for five to ten



FIG. 8.



FIG. 9.

FIG. 8. Demonstrates healed wounds eight days postoperatively. The incision over the sapheno-femoral junction will be noted. The classical ligation at this point is done in all cases in which varicosities involving the internal saphenous system are demonstrated in the thigh.

FIG. 9. This venogram demonstrates the fallacy of our conventional tests for the presence of perforators. The venogram was made by the method of Mahorner with the addition of pressure over the femoral vein just below the inguinal ligament. This pressure produced a flow of the diodrast from the deep circulation to the superficial through the incompetent perforator shown at "X." By clinical tests the major bulge in the vein between the two tourniquets had been found at "Y" about two inches distant.

minutes after all ligations are completed. If dilatation of any of the veins becomes manifest, it may be assumed that an incompetent perforator has been overlooked and further search is in order. Careful attention to details of interpretation will obviate the likelihood of overlooking perforators as the operation progresses.



A FURTHER STUDY OF EARLY POSTOPERATIVE AMBULATION

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MANY new surgical techniques and procedures, having been tried and found worthy, do not win general acceptance by the profession, due to a hesitancy to "try something new and radical." One such radical technique is the permitting of patients to rise and walk early after operation, disregarding the long period of bed rest which has become traditional. However, early mobilization after operation is not new. McDowell,¹ in reporting three cases of extirpation of diseased ovaries in December, 1809, reported on a woman who rose early without the doctor's orders, but also without mishap: "In five days I visited her, and much to my astonishment, found her engaged in making up her bed. I gave her particular caution for the future; and in twenty-five days she returned home as she came, in good health, which she continues to enjoy."

Leithauser,² an enthusiastic supporter of early mobilization after operation, reviewed the literature on the subject, saying that Ries,³ in 1899, routinely allowed his patients to rise early. In the late twenties many foreigners adopted the practice, reporting some 15,000 cases, among which were included Zava's⁴ 6,000 cases without pulmonary emboli or eventration.

In this country reports on early rising did not become prevalent until more recent years, but now reports are multiplying with large numbers of cases cited. Some of the more recent advocates of this mode of treatment are Leithauser,⁵ Nelson,⁶ Fisher and Burch,⁷ D'Ingianni,⁸ and Patricelli.⁹

Since prolonged bed rest after operation has become an established practice, let us examine the reasons for such a practice. It has been generally supposed that wounds heal more rapidly when the patient is im-

mobilized, and does not tear and pull at the suturing through exertion. The resting patient, it is believed, conserves his energy and allows his body to rebuild its injuries received through operation and previous illness. Finally, pulmonary emboli, which form about the third day, have time to dissolve during the long period of rest in bed.

On the other side of the story, the advocates of early mobilization claim that the value of prolonged bed rest during convalescence after operation is overestimated; indeed, that it is often detrimental to the well being of the individual to remain immobilized; that wound healing is actually retarded when circulation is slowed through inactivity.

Kimbarovskiy¹⁰ immobilized a group of dogs in plaster casts after operation, and allowed another group, similarly operated upon, to move about freely. He found the tensile strength of the wounds greater among those that moved about unrestrained. Newburger,¹¹ experimenting with rats, obtained similar results. Nelson,¹² reporting on children, and Zava¹³ reporting on mentally deficient patients, found their wounds healed as well, if not better, than the wounds of patients who cooperated by resting quietly for the prescribed period.

Fisher and Burch¹⁴ reported 1,494 cases of acute appendicitis in which the patients were allowed up to void eight hours after operation, and who were ambulant on the fourth day. The absence of phlebothrombosis and pulmonary emboli were pointed out; they found no interference with wound healing, and noted the early restoration of normal pulmonary and intestinal function. The patients were enthusiastic and exhibited no great discomfort because of their early activity.

The following report of 250 personally supervised cases of early mobilization are to be added to my recent report which included 153 cases. Of these 250 cases, ten were patients who were operated upon for cholecystectomy, ninety-five rose early after appendectomy, and 145, after laparotomies. The following table briefs the bedside notes of their stay in the hospital:

AVERAGE VALUES	
No. of days in hospital.....	5.8
Increase in temp., degrees F.....	1.9
No. of days fever persisted.....	2.1
No. of complications.....	0.02
Postoperative day diet was ordered.....	1.6
No. of hypodermic injections of narcotics.....	3.8
No. of catheterizations.....	0.03
No. of patients discharged with fever.....	0.0
No. of patients with chromic gut sutures.....	95.0
No. of patients with cotton sutures.....	155.0

This briefly summarized report conforms more closely to the reports of other advocates of early mobilization than did my earlier comparative report of 153 cases, largely because of the great reduction in the number of complications, in the duration of fever, and in the number of injections of a narcotic that were necessary.

The complications among the group herein reported were confined to one case of wound infection, which persisted until all of the cotton sutures placed in the fascia had been removed; two patients who developed persistent nausea and vomiting, which were relieved only by an indwelling duodenal tube; one who developed cystitis following a vaginal hysterectomy; and one patient who developed bronchitis. The number of severe complications that were encountered in the earlier report were not present in this group of 250 cases.

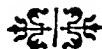
The number of injections of narcotics administered by hypodermic was extremely few, many patients required only one injection postoperatively, and the average was 3.8.

Although 250 cases added to 153 cases previously reviewed are not staggering figures as far as statistics go, and can in no manner compare with Zava's 6,000 cases, yet they become significant because they so consistently point out the advantages of early mobilization.

A prompt return to normal life after operation, without undue upset of normal body functions should be the aim and end of all surgical procedure. If increasingly more advocates of early mobilization report continued excellent results over a period of years, perhaps the tradition of prolonged rest in bed after operation may one day find itself shelved.

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DIRECT INGUINAL HERNIA

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DIRECT inguinal hernia can truly be considered the *bête noir* of all hernias, because of its etiological factors, rate of recurrences and unsatisfactory treatment. Even its designation as direct is ambiguous and illogical. Abdominal contents do not enter the hernial sac any more directly than those of the indirect variety in which the sac is already preformed and the neck open and inviting. The term, hernia into Hesselbach's triangle, is more significant but introduces the undesirability of a proper name whose significance may be non-informative to many. Hernia into or of the inguinal triangle is offered as a suggestion.

Compared to the indirect variety the etiological factors are really paradoxical. While the deep ring has much more ample protection by the trap door valve of the internal oblique muscle, reinforced by a firm fascia of the external oblique muscle, the caudad portion of the inguinal canal has as its sole support an attenuated transversalis fascia and skin. Still the former variety is four times more common. As these hernias are always acquired they appear only in adult life, usually in the fourth to the sixth decade. It can thus be assumed that this apparently weak area is nevertheless capable of withstanding the strain and stress of physical effort and increased intra-abdominal pressure for the major part of one's life. But to confound the problem further is the fact that recurrent hernias reverse the ratio of primary indirect to direct type.

SURGICAL ANATOMY

The triangle through which the sac protrudes or bulges is bounded by the epigastric vessels, Poupart's ligament and the edge of the rectus muscle. It may be of

different dimensions, the larger ones being more liable to be the seat of a hernia. The internal oblique muscle and the transversalis fascia are the tissues subject to most variations. The further away from the anterior superior spine the muscle takes its origin, the less protection it can offer as it contracts and straightens out its curving fibers to cover the canal; and if its tendon together with that of the transversalis muscle is inserted into the sheath of the rectus instead of the pubic spine, it removes additional support at the lowest angle. The muscle may be deficient in structure and therefore in contractility owing to the component muscle bundles being banded rather than in a uniform plate. Undoubtedly chronic wasting diseases may cause a deterioration.

The transversalis fascia may present a definite opening or defect, a bulge or attenuation or appear entirely absent. However, it is always present posteriorly and medially to the internal oblique muscle, even though it may be necessary to remove the overlying areolar tissues to identify it.

The sac, whether a saccule or bulge, may be peritoneum, bladder or bladder diverticulum or large bowel. If associated with considerable preperitoneal fat, it is suggestive of bladder tissue. But this is not to be confounded with the so-called gland of Rosenmüller which is merely a collection of isolated adipose tissue. In the case of the definite opening in the transversalis fascia, the protruding tissues may be incarcerated or even strangulated.

The peritoneum lining the anterior inferior medial abdomen has three definite fossae formed by the urachus in the mid line, the deep epigastric vessels laterally and the obliterated hypogastric vessel

between. The middle fossa is the seat for the direct hernia.

DIAGNOSIS

The diagnosis depends upon the perception of a protruding reducible mass

However, as the incision over the femoral region can readily expose the superficial inguinal ring the correct diagnosis can easily be made.

Cyst of the Cord. Usually there is an absence of any general discomfort, ab-

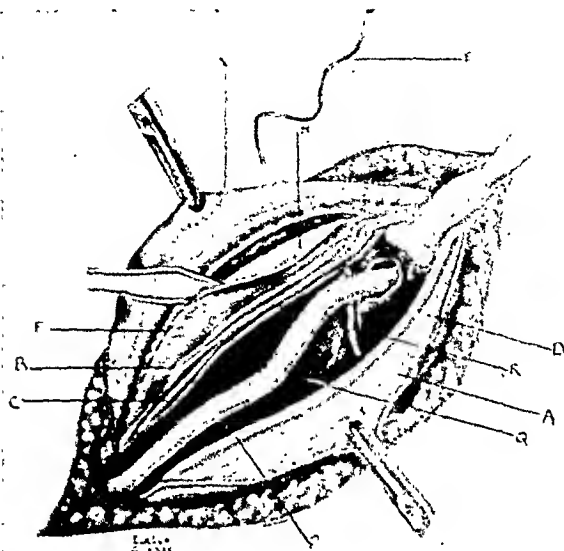


FIG. 1. A, aponeurosis external oblique muscle; B, internal oblique muscle; C, suture; E, epigastric vessel; F, cut edge of fascia internal oblique muscle; H, lateral leaf of cut internal oblique fascia; P, Poupart's ligament; T, transversalis fascia; R, incision transversalis fascia; S, uneut peritoneum.

through the superficial ring on increased intra-abdominal pressure. A mere impulse or the presence of a large ring does not constitute a hernia nor does it denote the potentiality of one. If the tip of the finger, inserted within the ring, with the palmar surface directed posteriorly, feels the mass on the ball, the hernia is of the direct variety; if on the tip, the hernia is the indirect form. A direct hernia never descends into the scrotum. On the other hand both may be and often are associated.

DIFFERENTIAL DIAGNOSIS

Femoral Hernia. While the uncomplicated femoral hernia should offer no difficulty, inasmuch as it emerges below the line running from the anterior superior spine to the pubic spine, the incarcerated one if sufficiently large almost always is directed upward to occupy the inguinal region, even though the bulk of it is below.

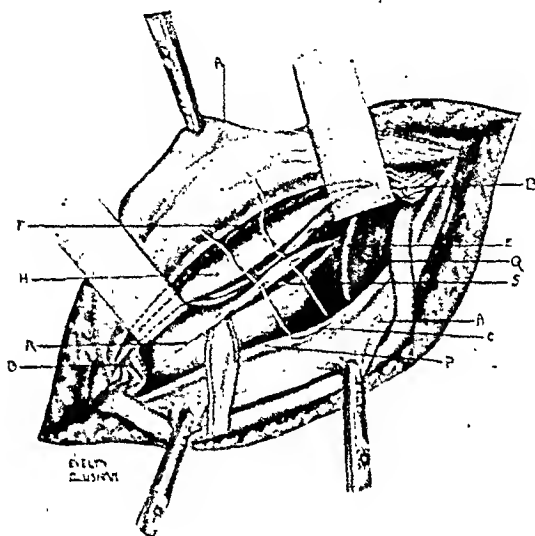


FIG. 2. A, aponeurosis external oblique muscle; B, internal oblique muscle retracted so as to show line of incision in transversalis fascia; C, mattress suture through flap of internal oblique aponeurosis, flap of transversalis fascia and Poupart's ligament; E, deep epigastric vessels; F, incision of aponeurosis internal oblique muscle; H, flap of internal oblique aponeurosis; P, Poupart's ligament; Q, transversalis fascia; R, incision in transversalis fascia over bulge of hernia; S, uneut peritoneum.

dominal symptoms or local pain. The tumor is rounded, partially movable but not reducible into the abdomen.

TREATMENT

The essential factors are (1) elimination of the cause if possible such as laborious occupation in a man over fifty, large abdominal tumor, ascites, etc; (2) adequate reinforcement by the use of homologous tissues; (3) good exposure at the pubic spine, avoidance of trauma, tension, oozing or infection; (4) utilization of the trap-door action of the internal oblique muscle.

Some of the fallacies of operative procedures are: (1) Using the same technic for the indirect as for the direct variety. (2) suturing the internal oblique muscle to

Poupart's ligament. It is not the author's intention to take up the old and oft repeated discussion of the union between muscle and fascial tissues, irrespective of the type of suture material. It is enough to state that in every case of recurrence it is noted that some part of the muscle has torn away from Poupart's ligament. It is plausible to expect this as repeated muscular contraction will tend to pull it away from its unnatural attachment. Furthermore, the normal and important trap-door closure action of the internal oblique muscle is thus entirely eliminated; and if and when the muscle is partially or completely freed from Poupart's ligament, it is weaker from disuse and atrophy than before operation and therefore invites a recurrence often larger than the primary hernia. The suture and attachment of the conjoined tendon to Poupart's ligament or Cooper's ligament is equally fallacious. These are all fixed structures and to approximate them necessitates tension, an egregious sin of any plastic operation. In a recent article this point is inadvertently mentioned by the author in advocating the use of heavy silk for approximating the tissues under tension, but any suture will cut through if the tension is excessive.

Author's Technic. The incision extends from the anterior superior spine almost to the pubic spine. It will be noted that this is longer than the usual Bassini incision but it is essential for good exposure at the lower angle and of the internal oblique aponeurosis. Hemostasis must be complete and separation and isolation of the structures must be by sharp and not blunt dissection, thus assuring a minimum of trauma. Intimate anatomical knowledge is a *sine qua non*. As the vascular supply of the aponeurosis is largely through the subcutaneous layer, it is advisable not to separate the latter widely to either side of the incision. After splitting the external oblique aponeurosis, avoiding injury to the ilio-inguinal and hypogastric nerves, Poupart's ligament is amply exposed laterally and the internal oblique fascia medially.

Upon splitting the cremasteric fascia longitudinally, the presence or absence of an indirect sac is determined. If even a small one is found, the peritoneum is freed and traction made thus pulling up the direct sac through the deep ring, opened, tied and

TABLE I
STATISTICS

	Direct Hernias	Direct Indirect Hernias
Total number.....	72	21
Not followed up.....	9	2
Less than one year since operation	4	13
Recurrences.....	59	19
Recurrence percentage.....	5*	1†
Suture Material	8.4	5.2
Fascia.....	23	5
Chromic No. 2.....	6	3
Chromic No. 00.....	7	4
Silk.....	21	7
Not specified.....	0	2
Cord transplantation		
Subcutaneous.....	22	4
Subaponeurotic.....	23	11
Infection (fascial suture).....	1	0
Age		
20-29.....	6	2
30-39.....	18	2
40-49.....	15	8
50-59.....	12	3
60 and over.....	3	4

* All fascial sutures.

† Age forty-five, recurred in three months, cord not transplanted, suture material chromic No. 2.

excess resected. With good medial retraction of the internal oblique muscle, the areolar tissue overlying the transversalis fascia is removed, the latter grasped and cut obliquely. The internal oblique fascia is then cut at and parallel to its fusion with the external aponeurosis and a flap developed and turned laterally to be sutured to Poupart's ligament together with the cut edge of the transversalis fascia. In some cases especially obese ones, it is easier to make two separate layers of suture to Poupart's ligament. Mattress sutures are used as they give a wider apposition.

Suture material, I believe, is of relatively minor importance, four series having been followed, using fascial sutures from the external oblique aponeurosis, fascia lata, silk and fine chromic No. 00. Tissues heal by traumatic inflammatory reaction followed by fibroblastic infiltration and ending in firm fibrous union. The only function of the sutures is to hold the flaps in contact during the lag period. It is desirable that the early inflammatory reaction be of the mildest type, such as is produced by chromic No. 00, very fine silk and alloy steel. A fascial suture fashioned from the external oblique aponeurosis or fascia lata and merely attached by a quarter of an inch at one extremity is to all intents and purposes devoid of its blood supply. When in addition it is woven into the tissues and subjected to trauma and tension, it must lose its viability. It therefore acts as a foreign, dead body even though it be autogenous and homologous. Clinically, this is borne out by the greater tissue reaction that takes place. In this

series the largest number of recurrences have occurred with the use of fascia.

CONCLUSIONS

1. Etiological and mechanical factors involved are still poorly understood.
2. Intimate knowledge of anatomical variations is essential.
3. Application of logical, surgical principles rather than stressing the importance of details, such as suture material, will eventuate in a higher percentage of cures.

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RELIEF OF PAIN IN OSTEOARTHRITIS OF THE HIP JOINT

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OSTEOARTHRITIS of the hip joint is a degenerative lesion, the etiology of which is not clearly understood. Its development has been attributed to various factors, as have osteoarthritic processes in other joints. Among these are, metabolic changes, infection, trauma, epiphyseal disturbances and congenital luxation without actual dislocation.

Briefly, the pathology consists of diminution of joint space and slight flattening of the head of the femur; proliferation of new bone around the head of the femur and margin of the acetabulum; the cartilage becomes worn over the head and in the acetabulum and is replaced by hard eburnated bone and the acetabulum grows larger as the head flattens, the femoral neck becoming short and broad.

X-ray findings show that in the early stages there is usually marginal spur formation, slight sclerosis of the opposing articular surface and slight narrowing of the joint space. In advanced cases the articular cartilages may be destroyed so that the eburnated bony articular surfaces are practically in contact; subarticular cystic changes and slight to moderate sclerosis of the intervening bone are often noted; marginal spur formation is more prominent.

Symptoms. The patient develops pain and stiffness of the hip joint and walks with a limp. The degree of pain is not necessarily in proportion to the amount of damage to the joint. Some patients with only minor damage may suffer severely, and others with marked destructive changes may have little pain.

The pain may be localized to the region of the hip joint, or more often it is referred to the lower portion of the extremity, to the knee or to a lower point, on the anterior surface of the leg, or lateral calf, the pathway of pain often simulating the pain of sciatic distribution.

This pain is purely reflex, being an intra-segmental reference from the painful stimuli arising in the structures about the hip joint. As in all cases of reflex pain arising from somatic structures, the area of pain reference has no tenderness of recognizable pattern and more often has no tenderness. Atrophy of the leg muscles is from disuse only. Sensory changes or alterations of reflexes in the area of pain reference are not present.

Observation to date, we believe, allows us to express the view that in many instances of severe pain arising from the lesion of an osteoarthritic hip joint, the pain does not come from the destroyed portions of the joint but from the peri-articular structures which have had undue stress and strain and alteration of function placed upon them as a result of displacement of the bony supports. In addition a low grade inflammatory reaction may be superimposed.

The structures which appear to be responsible for pain in most of these cases are the tendons of the gluteus minimus, gluteus medius, and perhaps, the piriformis. In most instances deep pressure over the tendons causes severe pain. These structures are most often responsible when the pain radiates to the calf.

We have been able, on repeated occasions, to relieve severe pain of short or long duration in osteoarthritis of the hip joint by conservative treatment consisting of a local infiltration of procaine hydrochloride.

Not all patients with osteoarthritis of the hip joint are benefited by this form of therapy. Only those patients exhibiting tenderness above and behind the trochanter should be infiltrated.

In order to determine whether or not an injection should be attempted, the patient is placed upon the examining table with

the painful hip up and the back toward the examiner. The thigh is flexed upon the abdomen to about 70 degrees. Above the trochanter, using deep pressure the tense and painful tendons can be palpated. From before backwards the gluteus minimus and the gluteus medius tendons can be felt. The piriformis insertion lies behind and below the top of the trochanter. At times the tensor fascia femoris anteriorly is tense and tender.

With the tender points marked, a 3 inch No. 22 gauge needle is inserted through a skin wheal, and 5 cc. of 1 or 2 per cent procaine hydrochloride is deposited at a depth which varies from 1 to 2½ inches. Pressure or needling at the

time of infiltration may cause the typical reflex radiation of which the patient complains. If no tenderness is present as compared to the opposite of unaffected side, injection is usually of no benefit. The injection may be repeated every fifth day.

Such cases of tendinitis occur also in the absence of an osteoarthritis of the hip and, because of the distribution of the reflex radiation into the leg, may at times, be mistaken for sciatic pain.

The progress of the joint disease, of course, is not affected by this procedure, but the results in many instances have been so satisfactory that the method appears to be of value solely for the purpose of relieving the pain.



It is possible for osteoarthritis to simulate protruded intervertebral disk; at times it may comprise a part of the general picture when a disk is present.

From "Surgical Treatment of the Nervous System" edited by Frederic W. Bancroft and Cobb Pilcher (J. B. Lippincott Company).

RECEDED CHIN

ITS CORRECTION WITH PRESERVED CARTILAGE

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FACES with receding chins are commonly regarded as weak. While this is not a scientifically proved fact, we do know that the chin which recedes disrupts the normal symmetry of the face. Popularly this type of asymmetry is regarded as homeliness, the degree depending upon the deviation from the accepted standards.

ETIOLOGY

New and Erich¹ catalogue the following factors as causative of the receded chin (microgenia): (1) Retarded mandibles due to malocclusion, (2) retarded mandibles due primarily to factors which arrest the growth of the lower jaw and due secondarily to the subsequent malocclusion, and (3) receding chins not associated with malocclusion. The third group includes chiefly the congenital type.

TREATMENT

The correction of receded chins due to malocclusion and arrested growth will not be discussed in this paper because they are essentially a problem for the orthodontist.

In the third group, namely, the congenitally recessive chin, the primary goal of the surgeon is to bring the size and shape of the chin to conform esthetically with the general contour and features of the face.

Various substances have been suggested for the purpose of correcting microgenia.

Paraffin. Kolle,² in 1911, advocated the use of paraffin and for many years this material was in vogue. However, its use was abandoned so that today it is rarely encountered except in patients unfortunate enough to have been subjected to these

injections. This is mentioned only to re-emphasize the danger of a paraffinoma.³

Ivory. Next in favor came ivory, which was popularized by Joseph⁴ and used by many others.³ After ivory, other foreign substances such as celluloid and various metals were advocated, their advantages being availability in unlimited quantities and the fact that they can be molded according to requirement.

Tantalum. Among these materials tantalum is particularly promising in that it causes little, if any, tissue reaction and so can be buried indefinitely in the body.⁵ Moreover, it is strong, light and malleable. Tantalum deserves a thorough trial in rhinoplastic and chin surgery.

Bone. Bone removed from the tibia or iliac crest has been and still is favored by some surgeons. The chief objection to bone is that it tends to become absorbed over a period of time, thus nullifying the favorably result obtained at the time of making the transplant.

Homocartilage Grafts. Cartilage obtained from the patient's rib for use as a graft probably has the greatest number of advocates. The primary advantage of cartilage is that it can thrive on meager nutrition. The objections to its use are that it entails the risk of an additional operation, and also that it leaves a chest scar. Again, if an infection should unfortunately occur, the two operations may then have been performed in vain. In fact, surgeons have been so concerned by this possibility that many bury unused cartilage under the patient's skin for use in such an eventuality. Lastly, cartilage tends to curl and bend, thus defeating the very purpose its use is hoped to accomplish.

New and Erich⁷ have devised a method to avoid curling.

Nasal Hump. Strangely enough, many patients with receded chins also have

cartilage. Experimental studies have demonstrated that septal and rib cartilage grafts preserved in alcohol and buried in human tissue are slowly invaded and re-



FIG. 1. A, front face before operation; B, front face after operation.

humped noses of varying sizes which accentuate the chin defect. Some surgeons have utilized the hump, after its removal by rhinoplasty, as a graft for use in correcting the chin deformity. This ingenious procedure, however, is not ideal, having the following disadvantages: (1) It is impossible to predict preoperatively that the size of the hump removed will be sufficient to correct the chin defect; (2) should an accident, such as contamination, occur, the graft would become useless; and (3) if the hump should break while being removed, it cannot be employed as a graft.

The fact that so many agents have been used as implants makes it clear that the perfect one has not yet been found. The ideal transplant should meet certain requirements: (1) Preferably it should not be a foreign body since this is not always tolerated by the host and may be expelled eventually; (2) it must be easily obtainable and in sufficient quantities; (3) it must be pliable; and (4) it should be preservable in a bank, without deterioration, for use at some later date.

Refrigerated Homocartilage. The most dependable and the most efficacious material so far employed is refrigerated

placed by fibrous tissue over a long period of time.⁶

A real contribution was made by O'Connor and Pierce⁷ when they revived the use

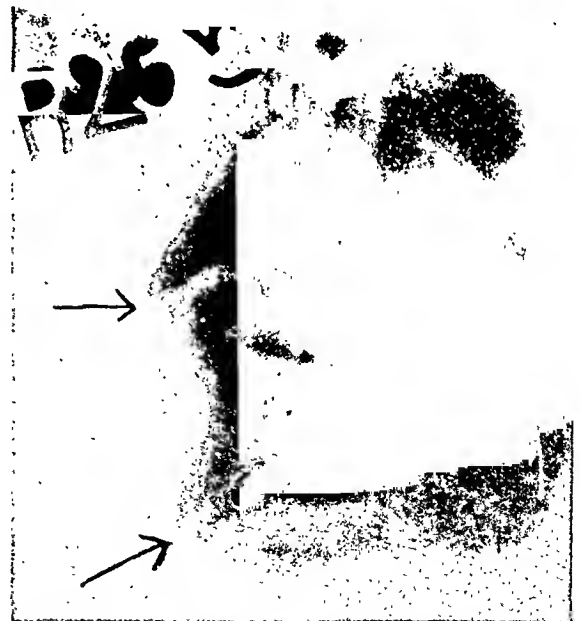


FIG. 2. X-ray, lower arrow showing position of graft; upper arrow showing malocclusion.

of refrigerated cartilage for grafts. In their latest report they describe its employment in 375 cases with only six infections, an enviable record indeed. Straight

and Slaughter⁸ have implanted refrigerated cartilage in 100 consecutive cases, 81 per cent of which were without complications

Fortunately, I had an appropriately-shaped piece of preserved cartilage in readiness for just such an emergency.



FIG. 3. A, profile before operation; B, profile after operation.

and 91 per cent of which were successful. My own limited experience with refrigerated homocartilage grafts has yielded entirely favorable results, certainly far more gratifying than those obtained with any other substance used for the same purpose. Although some authors have recommended obtaining cartilage from deceased persons known to have been free from syphilis and tuberculosis, my own preference is the cartilage removed at the time a sympathectomy for hypertension or a thoracoplasty is performed.

Cartilage Banks. Cartilage banks have been suggested⁹ and I agree that their use should be encouraged as far as possible. Chest surgeons should be asked to contribute to these banks all of their suitable material and hospitals not having a supply should be enabled to draw upon the cartilage bank according to their need.

CASE REPORT

The patient was a female, aged eighteen, whose microgenia was accompanied by a humped nose. (Figs. 1A and B.) Initially, it was intended to remove the hump and use it for building up the chin. Upon removal, however, the hump was not only insufficient in size but so friable that it broke into several parts.

Under infiltration anesthesia (2 per cent novocain and epinephrin solution 1:25,000) a horizontal submental incision was made, 1.5 cm. in width. In order to accommodate the cartilage implant a tunnel was formed close to the mandible and the cartilage inserted therein. (Fig. 2.) The skin was now sutured and, to insure the fixation of the graft, three additional sutures were passed through the skin covering the chin and through the cartilage. These latter sutures were removed twenty-four hours postoperatively.

The result was quite gratifying. (Figs. 3A and B.)

SUMMARY

A case of microgenia and a method of correction are presented.

Tantalum has been mentioned as a possible satisfactory graft material for use in the correction of facial defects.

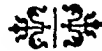
Portions of rib removed during sympathectomy or in the course of other thoracic surgery are an excellent source of cartilage, for correcting any facial deficiency, including microgenia.

Refrigerated cartilage is recommended as the most successful material used to date.

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OPERATION for harelip is usually indicated in early infancy. . . . Early repair of a cleft lip will minimize lip and nose deformity and aid in molding a coexisting deformity due to a cleft of the alveolar process.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

SAPHENOUS VEIN AS AN INTRAVENOUS ROUTE

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NUMEROUS articles have been published regarding various intravenous routes as a lifesaving measure when the usual veins are collapsed or cannot be found and utilized. We have often cut down on veins of an arm only to find them too small and contracted for satisfactory use, especially for repeated administrations of plasma or whole blood. Much has been written about intrasternal transfusion in adults and intratibial in children. These routes in my opinion, while of definite value, leave much to be desired. The speed with which fluids may be given by this method is not as great as we may desire. Since this is not a direct intravenous route, naturally it cannot compare with a direct one.

Too much care is usually needed to keep the needle free from plugging and despite the use of a good gauge needle and saline irrigations, stoppage occurs too often, especially when using whole blood; then again there is the possibility of osteomyelitis as a complication.

There are several advantages in using the saphenous vein of either leg. Primarily, the vessel may be located rapidly and easily. The vessel is certainly large enough to serve as a repeated transfusion vehicle for days. The vessel permits direct intravenous administration. Because of its size, this vein can always be suitable regardless of the shock and amount of circulatory collapse. It is indeed large enough to be of definite value in the newborn.

My first attempt at intrasaphenous transfusion came when a patient was admitted to St. Joseph's Hospital with complete burns of chest, back and both arms. Because of the edema and swelling, the cubital veins were not palpable. In the absence of any visible leg veins, it was

decided to cut down on one of the saphenous veins.

TECHNIC

The groin and the anterior surface of the thigh are prepared in the usual manner. An incision, about three inches in length, is made parallel to and about one and a half inches below Poupart's ligament on the anterior surface of the thigh. The middle of the incision should be just below the femoral ring. This is lower than the usual incision for the saphenous ligation for varicose veins. We are not interested in ligating its branches; just the exposure of the vein. The incision is carried through the superficial fascia. With blunt dissection, the loose areolar tissue is separated and the saphenous vein is easily located. In the adult, the normal size of the saphenous vein compares with that of a lead pencil. The loose fat is freed from the lateral and anterior aspects of the vein and a curved clamp is passed underneath until the saphenous is completely free. This operation should not take more than two or three minutes, since it is distinctly a minor surgical procedure. After exposure, the intravenous fluids are administered in the usual manner. The wound, in the meantime, is covered with sterile gauze or towels. If repeated transfusions are to be given, a retaining needle with stylet may be left in place; or the needle may be withdrawn and reinserted when needed. If the vein is to be used repeatedly, the wound is dusted daily with sulfathiazole powder and packed with iodoform gauze. At any time, this incision may be closed and healing by first intention will result.

CONCLUSION

In my opinion, the saphenous vein as an intravenous route can prove a lifesaving

measure when the usual subcutaneous veins are unsatisfactory. The method is far superior to the intrasternal or intratibial route since it permits direct intravenous administrations. Because of its size and location, the saphenous vein of either leg may always be satisfactory regardless of the amount of circulatory collapse. Intravenous saphenous administration should be ideal in maternity mishaps, such as postpartum hemorrhage, etc., because of the speed of direct vein transfusion compared to the intrasternal or intratibial method. Then again, during delivery, the groin and upper anterior surface of the thigh are already prepared and in case of emergency transfusion, the obstetrician need only to extend either leg and expose the saphenous without breaking a sterile technic.

The saphenous route should be of definite value in the newborn and in children, because of its size.

In extensive burns when the subcutaneous veins are obliterated because of the edema, the saphenous may prove to be the only satisfactory intravenous route for plasma or other fluids.

In general surgery, these veins may be used for continuous administrations during prolonged surgery. Again, by exposing one

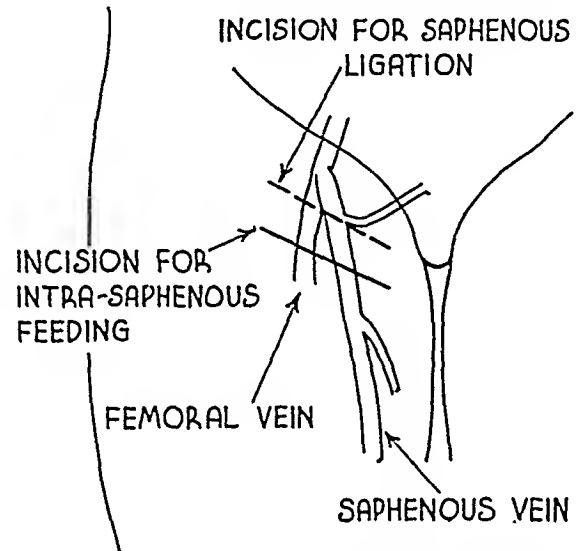
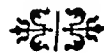


FIG. 1. Shows correct incision for intrasaphenous feeding compared to incision for a saphenous ligation.

or if necessary both of these veins, there need not be any excuse for depriving a patient of a needed transfusion or any intravenous fluids because of the inability to find a suitable vein. Internes may readily be taught the simple technic of saphenous exposure.



Case Reports

FOREIGN BODIES IN AND IN RELATION TO THE THORACIC BLOOD VESSELS AND HEART*

MIGRATORY FOREIGN BODIES WITHIN THE BLOOD VASCULAR SYSTEM

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DURING the past year, in addition to cardiac and pericardial foreign bodies, over seventy missiles have been removed from the mediastinum or other positions in relation to the great vessels of the thorax. In this series three cases stand out for they represent migration within intrathoracic blood vessels.

These migratory foreign bodies were all successfully removed and the patients have been discharged clinically well. The three case histories are presented here with descriptions and illustrations of certain aspects of the surgical technic involved.

The general comments are based on the cases presented and on forty-two cases previously reported. The indications for the removal of intravascular foreign bodies are discussed. Clinical support for these indications is cited from the medical literature and from the author's experience.

CASE REPORTS

CASE 1. This thirty-year old white male officer was wounded in the left infraclavicular region by a 30 calibre machine-gun bullet while in action against the enemy December 26, 1944. The wound was débrided and sutured the same day at a forward installation. Radiographic examination of the chest revealed that the bullet was located posterior to the hilum of the left lung. The patient was evacuated to the 128th General Hospital where it was decided

that the size and proximity of the bullet to the hilum of the lung were indications for its surgical removal. He was transferred to this Chest Center at the 160th General Hospital on January 8, 1945.

Admission films (Fig. 1) confirmed the presence of the 30 calibre machine-gun bullet in the hilar region of the left lung. The routine fluoroscopic studies for precise localization suggested nothing more remarkable than a pulsating bullet intimately associated with the hilar structures. It seemed obvious that this missile could best be removed through the conventional posterolateral approach.

On January 19, 1945, a thoracotomy was performed through the left posterolateral approach by resecting 12 cm. of the seventh rib. The bullet was immediately palpated in the central portion of the left upper lobe. This was confirmed by the first assistant. When the surgeon again palpated the lung he was chagrined to find that the missile had vanished. A thorough search of the entire lung, hilum, pericardium and posterior mediastinum failed to discover the bullet. It was then suspected that the missile had fallen into the tracheobronchial tree. Immediate bronchoscopy eliminated this hypothesis. The thorax was closed.

X-rays of the chest taken immediately after the operation (Fig. 2) were reported as follows: "Metallic bullet previously reported in the left chest is now visible lying horizontally just to the right of the body of D-6 pointing outward and apparently in relation to the pulmonary artery area." In view of this shift the missile seemed definitely in the right pulmonary

* Appreciation is expressed to the Sias Laboratories of the Brooks Hospital, Brookline, Massachusetts, for their assistance in the publication of this article and for the provision of facilities for further investigation in cardiac surgery now under way.

artery. The patient made an uneventful post-operative recovery. He was out of bed daily from the first day.

(Fig. 3.) The bullet, point outward, was then digitally manipulated away from the hilum into the pulmonary artery of the upper lobe.



FIG. 1. (Case 1.) Admission films. This 30 caliber bullet in the hilar region of the left lung was later shown to be within one of the radicles of the left pulmonary artery.



FIG. 2. Case 1. Films taken immediately after the left thoracotomy January 19, 1945. The missile is in the hilum of the right lung. The double image of the bullet in the lateral view is due to its pulsation with the pulmonary artery.

On February 20, 1945 a thoracotomy was performed on the right side, through the third intercostal space anteriorly. (Fig. 3, inset.) The third and fourth costal cartilages were divided close to the sternum. The bullet was palpated in the hilum of the right lung at and in the mediastinum posterior to the superior vena cava. There was no evidence of altered blood flow in the lung. The right pulmonary artery was isolated and a tape was placed about it proximal to the foreign body within the artery.

(Fig. 3, inset.) This "milking" process was continued until the point of the bullet presented beneath the visceral pleura in the interlobar fissure. The pleura was then nicked and the point of the bullet thrust through. This presenting tip was grasped with a Kocher clamp and the missile delivered by slowly stretching the terminal branches of the pulmonary arterial tree. Hemorrhage was controlled by circumferential mattress sutures of catgut in the lung about the point of removal. (Fig. 3, inset.) The

wound was closed without drainage. The patient was up and about from the first post-operative day and made an uneventful recovery. He was returned to the Zone of the Interior March 30, 1945, for rehabilitation.

lumen of the left pulmonary artery at the time of the first operation and was dislodged at the time of the exploratory palpation.

The technic of removing this bullet

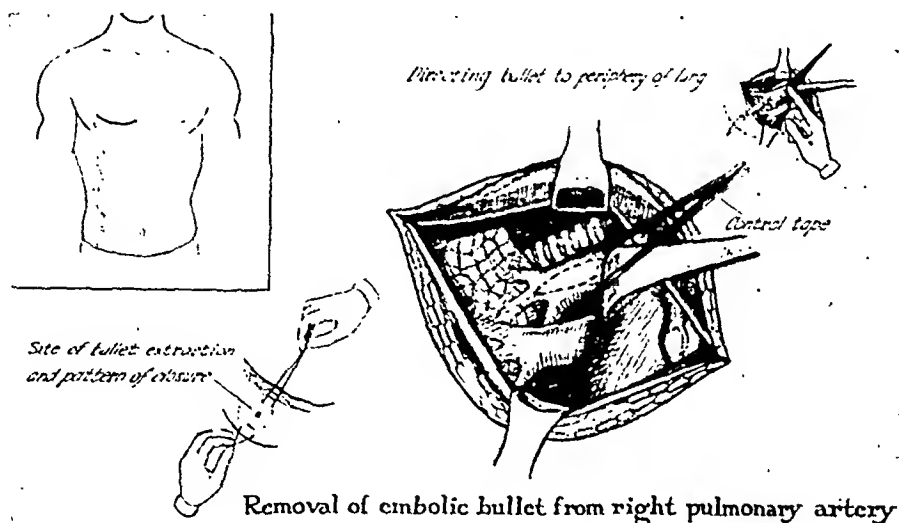


FIG. 3. Case 1. The dissection of the right pulmonary artery and the contained bullet is shown. The inset at the upper right indicates the bullet being milked out into the smaller radicles of the pulmonary artery. The left lower inset illustrates the opposing hemostatic sutures about the site of bullet removal.

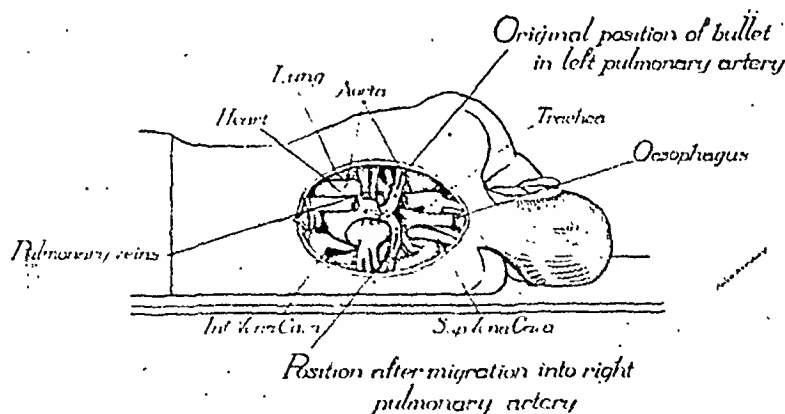


FIG. 4. Case 1. The course of migration of the bullet from the left pulmonary artery into the main pulmonary artery and then out into the right pulmonary artery is demonstrated.

The course of migration and the technic of removal have both been of interest to us. The migration of a foreign body from the left pulmonary artery into the main pulmonary artery and thence to the right pulmonary artery is illustrated in Figure 4. The foreign body evidently was in the

seems simple and obvious. Certainly this procedure was less formidable than opening the right horn of the pulmonary artery, removing the missile and attempting local main branch reconstitution of the vessel. We are not aware of the previous use of this maneuver.

CASE II. This soldier was wounded by a shell fragment that entered the upper part of his right posterior axillary line October 14, (4) because there was some question about fresh bleeding into the right pleural cavity. The possibility of fresh bleeding suggested



FIG. 5. Case II. Admission films show the shell fragment posterior to the right sternoclavicular joint in the region of the innominate artery.

1944, while in action against the enemy in France. The wound of entry was débrided and closed the same day at the 60th Field Hospital. X-ray studies of the chest revealed a foreign body in the right upper mediastinum 3 cm. posterior to the right sternoclavicular joint. (Fig. 5.) A right hemothorax was also noted and 500 cc. of blood was aspirated. The patient was evacuated to the 154th General Hospital where a pericardial friction rub was heard. On October 21, 1944, a bruit over the right supraclavicular fossa was discovered and it was noted that there was absence of the brachial and radial pulse in the right arm. Thoracentesis of the right chest repeated November 7, 1944, yielded what was thought to be fresh blood (later found to be old changed blood or so-called "grape juice blood").

In view of the above findings the patient was transferred to this Chest Center on November 10, 1944. On entry it was noted that the right hand was cooler than the left and waxy yellow in color. The blood pressure in the right arm was 102/80 while in the left it was 122/68. Fluoroscopic and x-ray examinations led to the belief that the foreign body was in relation to the innominate artery. (Fig. 5.) Surgical removal was considered advisable because of (1) the size of the fragment, (2) its proximity to the large vessels in this region, (3) evident vascular damage as attested by the bruit and blood pressure difference in the two arms and,

that such intervention should be instituted promptly.

On November 12, 1944, under endotracheal gas-oxygen ether anesthesia a U-shaped incision was made over the right upper anterior chest wall. (Fig. 6, inset No. 1.) The sternum was exposed. The internal mammary vessels were divided and ligated in the second intercostal space. The right pleural sac was opened widely, the deep surface of the sternum was cleared of underlying structures and the sternum was split with a power saw longitudinally in the mid-line from the suprasternal notch down to the level of and out through the right second intercostal space. (Fig. 6, inset No. 2.) The segment of sternum with the clavicle and first two ribs attached was reflected upward and outward providing excellent exposure of the superior mediastinum and base of the neck. The superior vena cava and the innominate veins were retracted with tapes. (Fig. 6, inset No. 3.) The innominate artery was isolated at its origin from the aorta and a tape placed about it for hemostatic control. The artery was then dissected free up to its bifurcation into the carotid and subclavian arteries and tapes were placed about each of these vessels. (Fig. 6, inset No. 4.) The foreign body was palpated within the upper portion of the innominate artery. The arterial wall was intact and free of scars. The artery was incised longitudinally and the foreign body removed. The intima in

relation to the foreign body was destroyed in a patchy fashion. Thrombi were removed following which both proximal and distal bleeding

from nine to fifteen minutes but going to forty-five minutes at one time. Immediately after operation the pulse was barely palpable

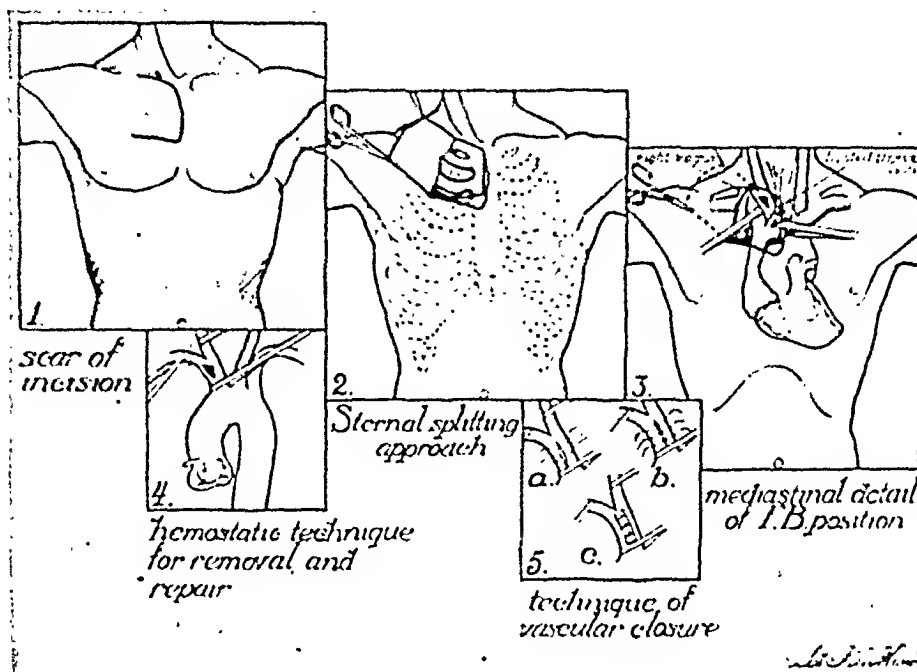


FIG. 6. Case II. This diagrammatic operative sequence demonstrates the removal of the missile from the innominate artery.

were free. The artery was then closed with interrupted No. 000 silk sutures in two layers. The first layer included the entire arterial wall. The second layer was placed through the adventitia and media, so placed that each suture took a bite on either side of the incision but did not pass through the lips of the incision. (Fig. 6, inset No. 5.) Fibrin foam was tied over the incision with the second layer of sutures. The sternum was drilled and approximated with three interrupted wire sutures. The drill holes for the wire were staggered, the medial ones being lower than the lateral so that when pulled tight, the sternal fragment was drawn downward and inward affording precise and stable reconstruction of the pectoral girdle. (Following operation stability is of great importance as movement of loosely held sternal fragments is both painful and shocking). The pectoralis muscles were approximated with interrupted No. 00 chromic catgut. The superficial fascia was closed with No. 00 chromic catgut and the skin was sutured with No. 1 black silk. No drains were used.

The patient was heparinized for three days following operation, the clotting time averaging

in the right arm. The first postoperative day the blood pressure was 122/80 in the left but unobtainable in the right arm. The second postoperative day, November 14, 1944, the right stellate ganglion was infiltrated with procaine. The right arm immediately became warm and a systolic blood pressure of 68 was obtained. On November 17, 1944, the blood pressure in the left arm was 132/60 while in the right arm it was 98/76. Thirteen days after operation the pressure was 124/86 on the left and 108/64 on the right. Hoarseness was present for four weeks following operation due to manipulation of the right recurrent laryngeal nerve but this disappeared. The postoperative hemothorax was evacuated by aspiration. The patient went on to recover with firm union of the sternum and suffered no circulatory disturbance. When the blood pressure was taken January 15, 1945, it was found to be equal in both arms. He was returned to the Zone of the Interior March 1, 1945, for rehabilitation.

Inasmuch as the wall of the innominate artery and adjacent portion of the aorta were everywhere intact at operation, it

seems that the course of the missile must necessarily have been through the right side of the chest and into the pulmonary vein or the left side of the heart. It was then carried as an embolus by the blood stream into the aorta and thence to the innominate artery where it lodged. (Fig. 7.) The pericardial friction rub noted prior to operation suggests that the pericardium was transgressed and that the foreign body entered the left side of the heart, thus entering the arterial circulation. In short, this case represents a penetrating wound of the heart or pulmonary vein with arterial embolism of the foreign body to the innominate artery.

The sternal splitting incision has been described in some detail. It has often proven useful in approaching the structures of the superior mediastinum or the base of the neck. No ribs are cut, nothing is resected and nothing is discarded. When the sternum is approximated carefully with wire, it heals rapidly and is functionally solid from the time of operation. The reverse of this incision through the left side of the sternum has been used in approaching the base of the left carotid and subclavian arteries at the aortic arch.

Surgical intervention in injuries of the innominate artery is perhaps always undertaken with some misgivings. Circulatory disturbances in the homolateral arm and a contralateral hemiplegia are possible complications. These misfortunes are unusual, particularly in this age group, but none the less stimulate the surgeon to restore vascular continuity when possible rather than ligate the innominate artery. This approach and technic served our purposes well.

CASE III. This twenty-two year old white soldier was struck in the right axilla at the level of the fifth rib by a machine-gun bullet July 15, 1944, while in action against the enemy in France. He was evacuated to the 159th General Hospital. Routine chest films taken there on July 17, 1944, were entirely within normal limits. (Fig. 8.) The lateral film adequately

established the retrocardiac zone as free of metallic missiles.

He was sent to the rehabilitation barracks symptom free. He had been there about three

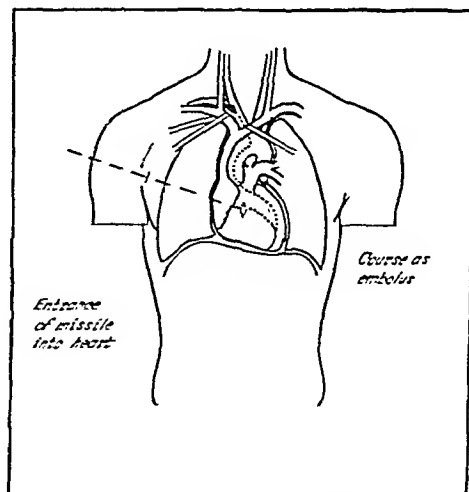


FIG. 7. Case II. The probable course of the missile from the left auricle, through the left ventricle and aorta to the innominate artery is represented.

weeks, enjoying a vigorous athletic program when, on the morning of August 13, 1944, at 2 A.M., he was awakened by agonizing pain in the lower part of the left side of his chest. This was accompanied by dyspnea, orthopnea, cough and hemoptysis. There were râles and diminished breath sounds over the left axilla.

On August 15, 1944, x-ray studies of the chest (Fig. 9) revealed a foreign body (30 calibre bullet) in the region of the hilum of the left lung. Bronchoscopy performed on August 9th revealed "edema and an injected bleeding point on the posterolateral wall of the left main bronchus." The continued hemoptysis and bronchoscopic findings indicated erosion of the bullet from the pulmonary artery into the left main or descending bronchus and transfer of the patient to this Chest Unit was thought advisable. This was done on August 22, 1944.

At this Chest Center it was agreed that the erosion of this bullet from the pulmonary artery into the bronchus constituted an urgent indication for surgical intervention.

Thoracotomy was performed on August 28th, through a posterolateral approach by resecting a 16 cm. segment of the left seventh rib. Exploration revealed discoloration of the lingular portion of the left upper lobe and to a lesser extent the anterior basic segment of the left lower lobe. Through the interlobar fissure the missile was palpated in the lower lobe and

hilum intimately associated with the artery. A fluctuant area about 1 cm. in diameter was noted over the base of the bullet. The hilum

stream issued from the defect. This was at all times completely under control as attested by voluntary release and then compression with



FIG. 8. Case III. Routine films of July 17, 1944, show clear lung fields.



FIG. 9. Case III. Films taken August 15, 1944. Two days after the sudden onset of pain in the left lower hemithorax a 30 caliber bullet is visualized in hilar region of the left lung. The missile was found in the left inferior branch of the pulmonary artery.

was exposed so that compression of the pulmonary artery could be effected by grasping the hilar structures from above downward between the surgeon's left index and middle fingers. This finger compression was not only hemostatic but served to stabilize the missile. Thus controlled, the fluctuant area was incised and the butt of the bullet found to lie in an abscess cavity anterior to and including the anterior surface of the lower branch of the left pulmonary artery. The body and point of the bullet, however, lay within the artery and when the missile was extracted the full arterial

hemostasis. The abscess cavity was carefully débrided and mattress sutures placed through its wall and the subjacent artery. Fibrin foam impregnated with penicillin was placed under the mattress sutures and the sutures tied, thus effecting a good closure of the vessel. The gangrenous lingular process was resected. The line of resection was closed with mattress sutures of No. 00 chromic catgut. The anterior basic segment of the lower lobe was considered viable and not disturbed. The lung re-expanded readily. Penicillin, 100,000 units, and 50 cc. of 2.4 per cent sodium citrate solution were

instilled in the pleural space and the chest wall was closed. The patient was up and about the ward within forty-eight hours. The postoperative left hemothorax was aspirated. The patient was discharged to a Rehabilitation Hospital December 1, 1944.

This case is striking because of the embolic nature of the foreign body as supported by symptomatology, x-ray studies and operative findings. There can be no question of confusion in the x-ray films as the patient's identification tags were included on the film at each x-ray exposure. Furthermore, his left first rib is characteristic in shape. The exact portal of entry into the circulation can only be surmised but as the chest is clear in the original films and the wound of entry in the lower axilla, it follows that the portal of entry was most likely in the liver. The bullet then began its course in the inferior vena cava, was carried to the right auricle, then to the right ventricle and out into the pulmonary artery. (Fig. 10.) The bullet entered the left branch of the pulmonary artery and lodged in the branch to the lower lobe and lingula in such a way as to occlude the arterial supply to the lingula as it arises from the lower lobe artery in this region. It is interesting that occlusion of the pulmonary circuit was associated with parenchymal change.

The method of controlling hemorrhage by hilar compression between the fingers of the surgeon's hand and the technic of closing the defect in the pulmonary artery were simple and functional.

COMMENTS

Strauss collected thirty-two cases of intravascular migratory foreign bodies and added one himself in a review of the medical literature in 1942.³ The authors have found nine additional cases in the literature prior to 1942,⁴⁻⁹ which, with those of Strauss, make a total of forty-two. Unquestionably, there have been other cases reported, especially in recent years. The following comments are based on these forty-two cases and the three

presented here. This communication is not intended as review of the literature, but rather as a general consideration of

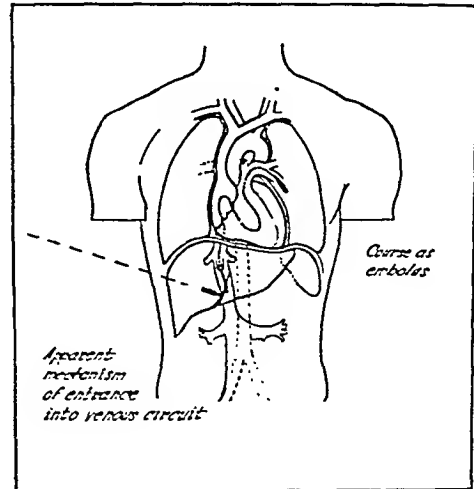


FIG. 10. Case III. The course of migration of the bullet from its entry into the inferior vena cava, through the right auricle and ventricle and out into the left pulmonary artery is indicated.

foreign bodies that migrate within the blood vascular system. The subject is interesting because of the infrequency of such incidents, also, the bizarre embolic course and dramatic developments that have characterized many of the cases on record. The majority of these cases have been associated with war wounds. The foreign bodies in almost all instances have been bullets or shell fragments.

Migration has occurred about equally in the arterial and venous circulations, depending on which the missile happened to enter.

In the arterial circulation the course of migration of foreign bodies and resultant clinical pictures vary with the portion of the arterial tree involved. In eleven of the forty-two cases the missile entered one of the larger arteries and passed peripherally as an embolus.¹¹⁻¹⁶ There were five instances in which the projectile entered the left ventricle and was swept out into the aorta to lodge within this vessel or its branches.^{8,10,11,12} In two cases the foreign body is said to have entered one of the pulmonary veins and passed into the left ventricle^{12,13} while in one patient

such a foreign body passed on through the left ventricle to become embolic to the right femoral artery.¹⁷ In two instances, missiles entered the ascending aorta and fell downward against the arterial stream. One came to rest in the sinus of Valsalva¹⁸ and the other in the left ventricle.¹⁹ One missile entered the pulmonary artery, migrated downward into the right ventricle and, seven days later, became embolic to the right pulmonary artery causing sudden death.²⁰ It is apparent that there is considerable latitude in the possible patterns of migration.

Varying degrees of arterial insufficiency due to embolic missiles have been observed. The extreme is the above fatal pulmonary embolus.²⁰ O'Neill observed transient blueness and coldness of the left leg caused by a shell fragment embolic from the left ventricle to the left common iliac artery.¹⁰ In one of the authors' cases (Case III) an embolic bullet in the lower lobe branch of the left pulmonary artery led to gangrene of the lingular portion of the left lung. This patient experienced severe pain in his chest when the migration occurred. In another of these cases (Case II) a diminished pulse and blood pressure were noted in the right arm following embolism of a shell fragment to the right innominate artery.

When the foreign body involved the venous circulation, in the majority of instances, the missile entered one of the larger veins, migrated to the right auricle and came to rest in the right ventricle. This occurred in nine of the group of forty-two cases.^{5,7,9,13,21,22} There were three instances in which the projectile entered one of the larger veins, was carried into the right auricle and then travelled down the vena cava to come to rest in one of the tributaries of this vessel.^{4,6,23} In another case a bullet entered the inferior vena cava and migrated to the junction of the common iliac veins.¹¹ There was one instance of the missile entering the right ventricle and then passing into the pulmonary artery.¹² In the case that Strauss

reported, a bullet entered the right common iliac vein and travelled to the left pulmonary artery.³ Death occurred four days later but was not due to the embolic missile. Waleher described a case in which the projectile entered the long dural sinus and then migrated into the sigmoid sinus.¹⁴ In another instance the missile entered the venous circulation through a thigh wound and was found at autopsy in the left ventricle of the heart.⁷ There was a widely patent foramen ovale.

Without going into exhaustive detail we have made an effort to point out the great variety of migratory patterns that have occurred in these cases as well as the relative frequency with which they are encountered. The possibilities are legion.

As a rule intravenous foreign bodies are asymptomatic. One patient who had a missile that had migrated into his right ventricle complained of pain over his heart.⁷

The case reported by Lyle serves to emphasize the danger of infection associated with intravascular foreign bodies. This patient died of a generalized gas bacillus infection. The wound of entry in the thigh showed no evidence of infection at autopsy. The foreign body, with fragments of clothing adherent to it, was found in the cavity of the right ventricle. There was a fibrinopurulent pericarditis and gas bubbles were noted in the myocardium. The missile with attached clothing was the apparent source of infection.

The patterns of migration in the three cases that are reported here deserve mention. The shift of a missile from one pulmonary artery to the other, and the migration of a missile to the innominate artery are both unique among cases known to us. Pulmonary embolism of a missile coming from the venous circulation has been reported.^{3,12}

Though one's fancy is stirred by the unusual nature of these cases, a pessimistic attitude is engendered as most of them have ended fatally. Among the thirty-three cases in Strauss' report only

six patients survived. The pathologist has generally been the one to remove the foreign body and to establish the course of migration.

Bearing in mind the possibility of missiles migrating in the blood stream, a careful search should be continued until the missile is located in all cases of penetrating wounds. If such a patient develops unexplained symptoms, use should be made of the fluoroscope and x-ray to ascertain whether or not a migratory missile is responsible.

With the progress of vascular and thoracic surgery and the tremendous advances in anesthesia of the past twenty years there will be few intravascular foreign bodies that cannot be attacked surgically. These advances have brought the thoracic blood vessels and the heart within the province of safe surgery. Such a viewpoint is supported by the three cases reported in this communication.

There are four cardinal indications for removing intravascular foreign bodies: (1) To avoid the hazards of vascular occlusion; (2) to diminish the dangers of sepsis (local and systemic); (3) to prevent erosion and hemorrhage; and (4) to remove the possibility of embolism.

Each of the above tenets has adequate support in the medical literature reviewed in this communication as well as direct confirmation within the experience of the authors. Tenet No. 1 is well demonstrated in the gangrenous lingular portion of the left upper lobe in Case III. (This theoretically should not have occurred in the presence of a normal bronchial circulation.) Tenet No. 2 is represented by Lyle's case in which there was a fatal septicemia. The embolic missile, found in the right ventricle of the heart, was the source of infection.⁵ Tenet No. 3 has been abundantly emphasized. Recently one instance each of fatal hemorrhage from erosion of the aorta and pulmonary artery has come to the authors' attention. Tenet No. 4 has its elaboration in the substance of this article.

In closing, the authors would like to emphasize four simple technical points that have been helpful in these and a number of other operations on the mediastinum: First, the liberal use of sternal splitting with firm craftsman-like fixation at the end of the procedure has provided good exposure at operation and has minimized this source of postoperative pain and shock. Second, manipulation of the missile from the right main pulmonary artery to the periphery in Case I has the advantage of surgical intervention in the relatively safe peripheral zone rather than in the more hazardous hilar region of the pulmonary artery. Third, the finger tourniquet grip used for hemostasis in Case III is a useful maneuver whenever bleeding from a lung is encountered. Fourth, the use of the patient's position on the operating table and direct fixation of the missile to prevent migration during the operative manipulation have been illustrated.

Unquestionably the surgical experience of this war will broaden our knowledge of this field and point out important technical aids in the surgical management of individual cases.

SUMMARY

1. Three cases are reported in which migratory missiles were successfully removed from intrathoracic blood vessels.
2. Salient aspects of the surgical technic employed are presented.
3. Forty-two cases of previously reported foreign bodies that have migrated within the blood vascular system are reviewed and commented upon.
4. Four cardinal indications for the removal of intravascular foreign bodies are presented with clinical support for each.

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THE effects produced by *gunshot wounds* vary according to the velocity and size of the missile and the area wounded, from a simple drilling or perforating wound to extensive disorganization or explosive disruption of tissue.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

CONGENITAL ATRESIA OF THE BILE DUCTS

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SINCE Thomson's²¹ careful analysis of fifty-two cases in 1892, there has been an increasing interest shown in the surgical management of congenital atresia of the biliary ducts. Such developmental anomalies were pathologic curiosities until Holmes made a detailed study of one hundred such cases and claimed that some could have been relieved by operation. The first successful operation of this type was performed by Ladd in 1927.¹⁴ The purpose of this report is to record two additional cases of atresia of the biliary ducts which recovered from operation. These patients serve to illustrate some of the surgical features in the management of this disease.

There have been few changes in the etiological and pathological concepts of congenital atresia of the biliary ducts in recent years. These topics have been adequately discussed in other reports.^{5,6,9,14,15,20}

The diagnosis is not easy to make, and usually is only proven at operation or autopsy. Errors may also occur in interpretation of the operative findings. This may have been the case in the second patient discussed in this report. Donovan⁶ reports two cases which were found to be inoperable at operation, there being no evidence of extrahepatic biliary systems, and the patients were living, free of jaundice or retarded development, two and a half and three years later. Such are the exceptions, however. The majority found to be inoperable have died within two years and autopsy showed no extrahepatic biliary ducts with marked cirrhosis of the liver.

CASE REPORTS

CASE 1. Baby B., a male infant born at full term by spontaneous delivery on October 12, 1944, appeared normal at birth but on the third day developed jaundice which increased in severity. The stools were acholic, and the urine showed bile and was dark in color. The baby's temperature was the intermittent type ranging from 101°F. to normal. The blood count showed 55 per cent hemoglobin with 4,320,000 red blood cells. Wasserman tests for the parents and the baby were negative. At birth there was a marked overriding of the bones of the skull which disappeared at the end of two weeks, as shown by x-ray. Two other children in the family were perfectly normal. The baby became progressively worse with increasing jaundice, marked emaciation, dehydration, diarrhea (steatorrhea) and loss of weight. Prothrombin time was twenty-five seconds compared to sixteen seconds for control prior to operation, and the patient was considered a very poor operative risk. In preparation for operation, injections of vitamin K, subcutaneous saline and small blood transfusions were given.

Physical examination revealed a well developed, white, male infant, alert, but with a rather weak cry. The birth weight was seven pounds one and one-quarter ounces. There was a marked degree of jaundice of the skin and sclera. The diapers showed marked bile staining from urine. There was an abnormal amount of fusion of the fontanel. Posteriorly the skull bones were overriding. Eye, ear, nose and throat findings were essentially negative. The heart and lung findings were normal. The abdomen was distended with prominent veins visible in the epigastrium. The liver was enlarged to the umbilicus. No other organs or masses were palpable. The genitalia and ex-

tremities were normal in development. The Pediatric Department diagnosed the case as congenital malformation of the biliary duct

ration and coramine. With the patient's condition improved, the dissection of the blind end of the common duct was resumed in prepa-

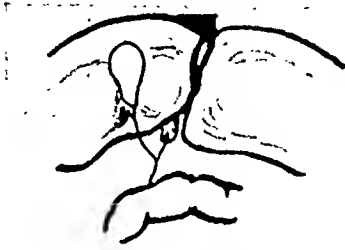


Fig. 1. 3 cases

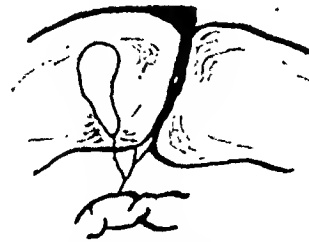


Fig. 3. 31 cases

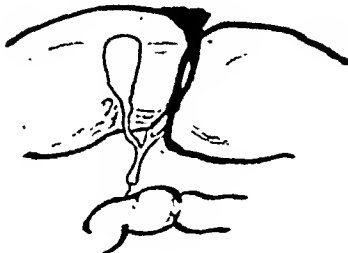


Fig. 2. 6 cases

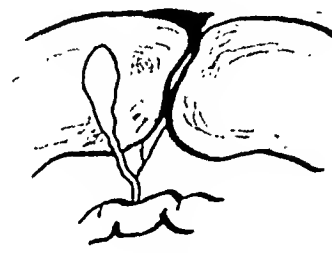


Fig. 4. 5 cases

FIGS. 1 to 4. Illustrations of the four most frequent types of anomalies encountered in Ladd's series of forty-five cases. Figures 1 and 2 are the types most amenable to surgery.

system with resultant obstructive jaundice, requiring early exploration.

On the twelfth day, under local and general anesthesia (ether), through an upper right rectus muscle-splitting incision, an abdominal exploration revealed an enlarged plum-colored liver. The right lobe was retracted to expose the gallbladder which appeared normal in size, shape and position. From the gallbladder neck, the cystic duct was dissected from the gallbladder to the junction with the common duct. The rest of the biliary duct system was dissected in the hope of finding the obstruction. Local anesthesia was used up to this point in the operation because of the poor condition of the baby, but to keep the patient quiet during the tedious, minute dissection, we deemed it advisable to give open drop ether for a short period. The common duct was found to terminate in a bulbous end a short distance from the duodenum, with only a fibrous cord distally. The anomaly was similar to that seen in Figure 2. In dividing the fibrous cord no lumen was found. At this point respiratory failure ensued. Resuscitation was accomplished by transdiaphragmatic massage, artificial respi-

ration for choledochoduodenostomy, which is most desirable (Ladd). We proved that the gallbladder was connected through the cystic and hepatic ducts to the liver in a normal manner by aspirating bile from the gallbladder, and therefore chose cholecystogastrostomy, which is technically easier to perform but suitable only in cases illustrated by Figure 2. The anastomosis was completed by two rows of sutures, inner No. 000 chromic catgut, outer row of 36 alloy steel over a short piece of No. 10 F. catheter, used to maintain the lumen. The abdomen was closed without drainage in three layers, using chromic catgut No. 00 for peritoneum and posterior sheath, anterior sheath of rectus united with interrupted 35 wire, subcutaneous fat and skin 35 and 38 wire.

The jaundice began to improve rapidly the day following operation. The stools and urine became normal in color. The baby retained fluids and formula and gained weight. By the third day the temperature range was 102.2°F. to normal. On the fifth postoperative day the wound showed redness, induration and evidence of beginning separation and imbedding of sutures. The wound edges separated down to

the anterior sheath after removal of the sutures. Aerobic and anaerobic cultures showed no pathogenic organisms of note, therefore, we

having had relief from jaundice of the obstructive type immediately after operation, and freedom from symptoms for



FIG. 5.



FIG. 6.

FIG. 5. Baby B. on the twelfth postoperative day, showing marked separation of skin and subcutaneous tissues.

FIG. 6. Baby B. nine months postoperatively, with complete healing of the wound and showing normal development.

believed that the distention, dehydration, icteric skin and liver dysfunction were features which contributed to the wound disruption. However, after treatment with various other measures, zinc peroxide paste rapidly promoted wound healing in three weeks.

Twenty-four days postoperatively, the baby developed a sterile abscess on the left thigh at the site of repeated injections of vitamin K. The patient was observed in the hospital for four months, awaiting adoption. Two months postoperatively a stool fat analysis indicated impaired fat digestion, total fats 26.6 per cent wet and 51.1 per cent dry. The baby was not examined again until twelve months later when it showed normal development without any biliary symptoms.

Comment. This case, fortunately, was one of the 20 per cent anomalies (Ladd)¹⁶ that was amenable to surgery, the patient

fourteen months. Our objective was to establish a connection for the biliary system directly with the duodenum or stomach. Early operation is advantageous in such cases in which jaundice, dehydration and loss of weight increase the risk. Many cases that Donovan,⁶ Ladd^{14,15,16} and others have reported were not explored until from one to five months after birth. Prolonged periods of procrastination will only lead to emaciation, biliary cirrhosis and fatal outcome.

Although great relaxation cannot be obtained by local anesthesia, our experience from this case leads us to believe that general anesthesia (ether), as usually recommended, is hazardous. The use of a short tube, No. 8 or 10 F., was necessary to maintain the lumen during formation of

the cholecystogastrostomy. To prevent the tube (No. 10 F. catheter one inch long) from slipping back into the gallbladder or

tostomies or cholecystogastrostomies which at autopsy revealed the gallbladder to have no connection with the biliary ducts

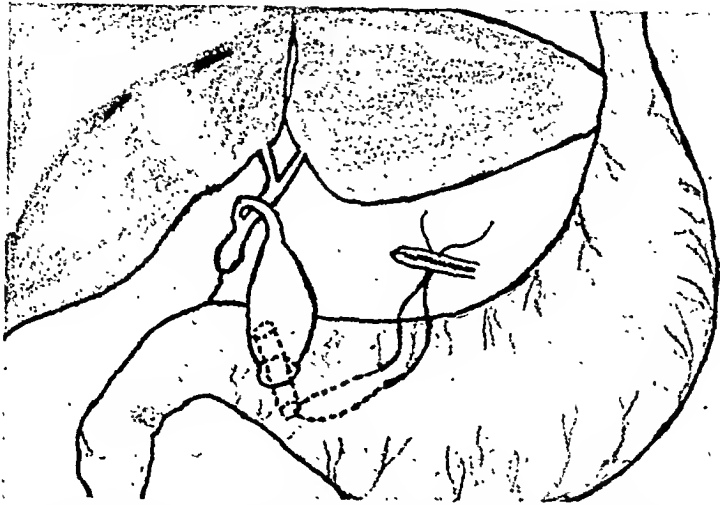


FIG. 7. Illustration of No. 10 F. catheter in anastomotic stoma which is ready to be pulled into the stomach by the suture through the end of the tube and the anterior wall of the stomach. The suture is removed and the tube allowed to pass through the intestinal tract.

remaining lodged in the stoma, a suture was passed through the end of the tube, then through the stomach wall from within outward. This suture was used to pull the tube into the stomach at the completion of the anastomosis after which it was removed. The tube was followed by x-ray until it was passed by the rectum at the end of three days. One case is recorded in which the tube remained at the site of anastomosis and ulcerated into the free peritoneal cavity, causing a fatality.¹⁴

Zinc peroxide dressings in the treatment of wound disruption proved most beneficial. Debility, abdominal distention and jaundice are the main factors in causing wound disruption which is commonly experienced in these cases. Closure of the wound in layers with alloy steel interrupted sutures has been efficacious in preventing complete wound disruptions and eviscerations. Painsstaking care with thorough dissection of the extrabiliary duct system is essential in determining the type of operation to be used, and for the success of the operation and survival of the patient. This fact is well illustrated by cholecys-

or the liver. The obvious lesson to be gained is that one should have good evidence that the gallbladder connects with the liver or biliary system before anastomosing it to the gastrointestinal tract.

CASE 11. Baby C., a normal full term female of spontaneous delivery, weighing six pounds two and one-half ounces, was born November 14, 1944. There were no external evidences of any congenital abnormalities. The second day after delivery the baby became markedly jaundiced, and the jaundice continued to increase without remission. The stools were acholic and the urine deeply bile-stained. Red blood count was 3.85 mil., 80 per cent hemoglobin, 19,500 white blood cells. Two days later the red blood count was 3.90 mil., 77 per cent hemoglobin, 11,400 white blood cells, normal differential, R.H. factor negative, type 4-0. The patient responded to two transfusions of citrated blood, 100 cc. each. Diagnosis at first was erythroblastosis fetalis and was later changed to obstructive jaundice due to congenital atresia of the bile ducts. With no clinical improvement after ten days, the baby was referred for exploration.

Under local anesthesia, a right rectus incision was made from the costal margin to the umbilicus. The abdomen was explored, viscera

site of the common duct. The abdomen was closed in layers with all steel wire (35).

Following the operation there was no im-

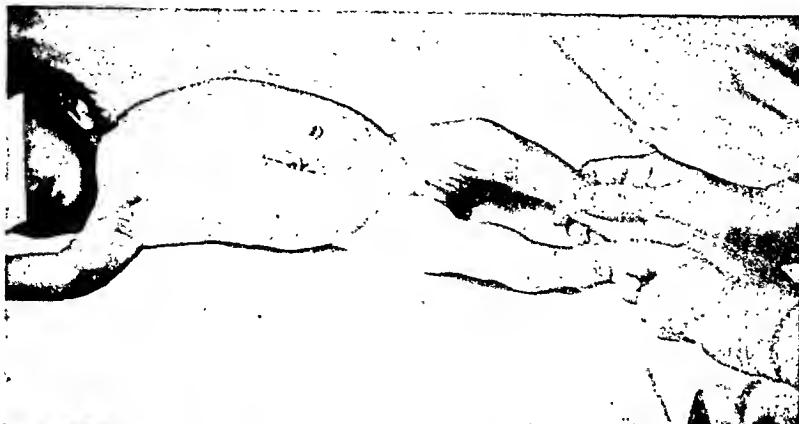


FIG. 8.

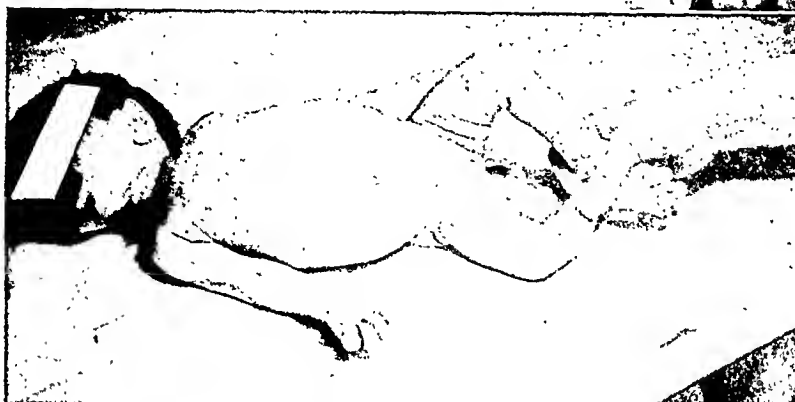


FIG. 9.

FIG. 8. Baby C. seven days postoperatively, showing the catheter through the wound extending down to the inferior surface of the liver. Also note the separation of the wound edges.

FIG. 9. Baby C. one month postoperatively, showing the wound well healed but emaciation, abdominal distention and jaundice still present.

packed off and the liver edge retracted. The gallbladder was visualized as small and normal. Dissection of the cystic duct was begun at the gallbladder. No cystic duct could be found, but only solid fibrous cords of tissue leading to a similar cord of tissue representing the common duct. Dissection was continued above to the hepatic duct, but no normal bile passage could be located. These solid cords were divided. Attempts to probe the duct were unsuccessful. After two hours of exploration with the biliary system exposed, we concluded that this was an inoperable case with an anomaly similar to that in Figure 3 which is the most common type found. A No. 20 gauge needle was used to aspirate the gallbladder which contained only a small amount of clear mucus showing no bile or connection with the liver. With the hope that some minute biliary radicle might drain off the bile, a small catheter was left along the inferior surface of the liver at the

provement in the jaundice for one month. No bile or fluid ever drained from the catheter. There was no demonstrable improvement for six weeks after which time the stools became gradually darker in color and the jaundice decreased. Although the baby retained the formula well, she did not gain any weight for five weeks. The wound separated from end to end down to the anterior sheath of the rectus on the fifth day. Wound cultures were negative. The incision healed rapidly with zinc peroxide dressings. The baby has progressively improved during the past twelve months and appears to be developing normally in every respect.

Comment. This case, in contrast to the one previously discussed, was of the common type of malformation (Fig. 3) which represents 68 per cent of Ladd's series. Similar cases have been reported by Donovan and Finlayson in which thorough

exploration found the patients inoperable. Three of these patients lived two and a half and three years. The supposition gained from this case is that we overlooked or were unable to find the minute duct. This does not appear to be so, because unlike the previous case in which the jaundice began to clear the following day, this case took six to eight weeks before the jaundice disappeared. Nothing was gained through attempts at external biliary drainage by catheter. Cholecystoduodenostomy in this type case is contraindicated especially when no bile was found in the gallbladder. Ladd re-explored such a case and found an excellent anastomosis, but there was no connection from the gallbladder to the biliary system or the liver, and autopsy confirmed the finding that no extrahepatic ducts were present.

SUMMARY

1. The common types of deformities encountered in congenital atresia of the biliary ducts are discussed, showing those which are operable.

2. A report of one of the operable cases is recorded with recovery following a cholecystogastrostomy.

3. A case report of one of the apparently

inoperable types of deformity with no extrahepatic ducts found at operation, which recovered from operation and is living and well at the end of thirteen months.

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SPONTANEOUS RUPTURE OF THE APPARENTLY NORMAL SPLEEN

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THE purpose of this paper is to add to the literature two more cases of rupture of an apparently normal spleen occurring in individuals from whom no definite history of trauma could be obtained.

Spontaneous rupture of the normal spleen has been reported in approximately thirty-six cases. In 1937 Zuckerman and Jacobi reviewed the twenty-eight cases in the literature and accepted twenty-one of them. Since 1937, eight papers containing case reports have appeared.

Spontaneous rupture of diseased spleens occurs and is reported more frequently. The literature reveals that such ruptures have taken place in patients who have had malaria, typhoid, leukemia, portal thrombosis, Banti's disease, infectious mononucleosis, splenic infarct, puerperal sepsis, relapsing fever, pneumonia and typhus. These pathological states have caused the development of splenomegaly and soft boggy spleens which have been the basis for the ruptures. Hemangioma of the spleen has resulted in spontaneous rupture also.

Delayed hemorrhage from traumatic rupture of the spleen constitutes another category of extraordinary splenic hemorrhage. Zabinski and Harkins reviewed the literature in 1943 and collected 177 cases of delayed splenic rupture and hemorrhage and added four of their own. They estimated that 14 per cent of traumatic rupture of the spleen were of the delayed variety. These cases all have a connected and definite history of trauma.

CASE REPORTS

CASE 1. A thirty-five-year old, white American soldier entered the Station Hospital, Grenier Field, Manchester, N. H., at 6:30 A.M.,

February 12, 1943, with the chief complaint of abdominal pain of nine hours' duration. On the evening of the day before admission he began to have a steady non-radiating pain in the left side of the abdomen slightly below the level of the umbilicus. There were frequent exacerbations of the pain. He was unable to sleep during the night, was nauseated, and felt as though he needed to move his bowels. He tried to move his bowels several times and could pass neither feces nor flatus. At 5:45 A.M., while trying to defecate, he had a sudden acute, severe exacerbation of the pain which caused him to cry out and roll about in great agony. An ambulance was called and he entered the hospital.

There were no urinary symptoms. His bowels had been regular, and moved usually two to five times a day, soft formed stools. He was said to be a voracious eater and his soldier mates insisted he had food poisoning from eating enormous quantities of unusual combinations. It was stated that he did not use alcoholic beverages.

There was no history of food discomfort or abdominal pain. The patient stated, however, that eight years previously and again two years previously he had had similar attacks relieved finally by little white pills his doctor gave him. They made his bowels move, he stated, and this relieved the pain.

There was no history of trauma, weight loss, or relevant past, family or system history. He had gained steadily in weight for several years and at time of entry weighed 225 pounds.

The patient was seen at once on entry to the emergency floor. He was rolling and twisting on the litter and crying out almost hysterically with pain. He was a short (5 feet 5 inches) obese man, thirty-five years old. His skin was of good color, warm and dry. There was no indication from the patient's general appearance that he was suffering from a serious or catastrophic lesion.

The general examination was not remarkable; the positive findings were located in the abdomen. There was prominence without dis-

tention. The left side of the abdomen was moderately tender especially just below the level of the umbilicus. There was voluntary muscle spasm in this area and mild rebound tenderness. No masses or organs were felt. No evidence of fluid in the abdomen could be made out. Peristalsis was present but diminished. Over the ninth rib in the left mid-axillary line was a small faint ecchymotic area. He was again asked about trauma and denied having sustained any. Rectal examination was negative.

Blood pressure was 120/80, pulse 90, temperature, 99.0°F., respirations were normal and not painful.

Because the patient was complaining so severely of pain, and evidence sufficient to consider surgical intervention was not present, the patient was given morphine, gr. $\frac{1}{6}$, and atropine gr. $\frac{1}{150}$. Intestinal obstruction, renal calculus, pancreatitis, diverticulitis, perforated ulcer and vascular accident were considered as possibilities. He was observed and studied for ten hours. His red blood count was 4,200,000; 85 per cent hemoglobin; 8,300 white blood count; 69 per cent polymorphonuclears; was normal. Flat plates of abdomen in various positions were negative as was an intravenous pyelogram.

He was partially relieved by the morphine. He did not appear acutely ill during most of the period of observation. However, his abdominal pain continued and the tenderness spread upward, across the abdomen, and he complained of pain on breathing, especially on top of the left shoulder. His blood pressure and pulse remained the same. His temperature rose to 99.6°F. The white count nine hours after admission was 14,000 with 77 per cent polymorphonuclears.

It was believed that he had a spreading peritonitis and that exploration was indicated. Twenty hours after onset of pain, under spinal anesthesia, a left transverse incision just above the umbilicus was made. On entering the peritoneal cavity a large quantity of blood was encountered. Exploration revealed the spleen to be enlarged. The exploring hand brought forth old clots from the region of the spleen thus making the probable diagnosis. The incision was enlarged and the spleen removed. It was approximately three times normal size and had an old, large subcapsular hematoma which had ruptured. It was estimated that

there were $1\frac{1}{2}$ to 2 liters of blood in the abdomen. The patient was given blood during and after the operation. Except for a mild wound complication and a short postoperative period of atelectasis, the convalescence was very satisfactory.

Pathological examination was as follows: Formalin fixed spleen 13.0 by 9.5 by 6.0 cm., weight 411 Gm. Capsule is slightly torn at anterior edge near lower pole. The denuded area measures 3.0 by 1.0 cm. Adjacent to the tear in the capsule is a dark blue-gray hematoma approximately 3.0 cm. in diameter. The remainder of the capsule is smooth and does not appear damaged. Sectioning reveals a layer of blood clot 0.4 to 0.2 cm. in thickness beneath the capsule, forming the hematoma. Beginning at the lower pole and immediately adjacent to the hematoma, the pulp contains a partly encapsulated, soft, reddish-black blood clot 2.0 by 2.5 cm. in diameter. It extends toward the upper pole of the spleen, increasing to a maximum diameter of 4.0 cm. in the middle of the spleen. The clot is approximately 9.0 cm. long. It does not extend into the upper quarter of the splenic pulp. Microscopic: Large amount of blood is found within splenic pulp just below the capsule. It extends toward the central portion. The sinuses within the pulp about the hemorrhage are dilated. The splenic pulp is otherwise not remarkable. Diagnosis: Hemorrhage of spleen, probably traumatic.

Blood studies revealed no evidence of malaria or blood dyscrasia. Careful questioning revealed no previous illness that might have given rise to a diseased spleen. Further, the question of trauma was again carefully gone into. All that could be obtained was the information that he had slipped and fallen on the ice several times during the winter which experience he had had every winter. He could recall no incident of injury to the left chest or abdomen or any fall which was followed by discomfort. Especially was he questioned regarding abdominal discomfort, weakness and shoulder pain prior to the onset of the acute illness.

It may be noted that in spite of the extensive intra-abdominal bleeding, the patient's appearance at no time suggested this. The clinical findings were rather those of spreading peritonitis. This florid individual apparently was able to lose considerable blood without giving rise to a picture of acute anemia.

The patient was discharged six weeks postoperatively to convalescent leave. Except for postoperative ventral hernia repair he has remained well.

patient in severe shock. He was pale, cold, and clammy. The radial pulse was regular, rate 100, but rarely perceptible. The blood pressure was 70/40 in both arms. There was no evidence

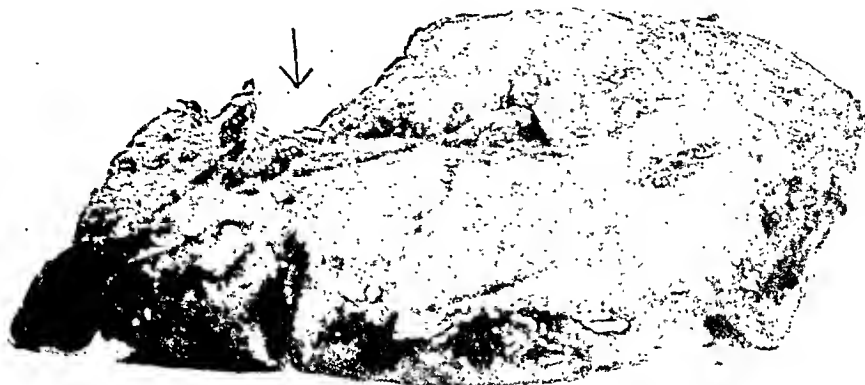


FIG. 1. Spleen from Case 11 with arrow pointing to rupture of right superior posterior border.

CASE 11. A forty-nine-year old Colonel entered the Station Hospital, Fort Monroe, Virginia, with abdominal pain of four hours' duration. The clinical picture was typical of a perforated peptic ulcer. In addition he had evidence of a moderate degree of bronchitis. For the past year he had had vague epigastric pain with occasional vomiting and a loss of 20 pounds in weight. The pain was periodic and slightly relieved by food. For the week previous to hospital entry, the pain had been almost constant, more severe, and relieved only by alkalis. He had vomited several times daily during the week. He was operated upon shortly after entry under spinal anesthesia. A perforated ulcer on the anterior aspect of the duodenum was found and closed by simple suture and reinforced with omental tissue. The readily available stomach and duodenal contents were aspirated and the wound was closed without drainage. During the operation, the splenic area was not invaded in any way.

The immediate postoperative course was smooth except for moderate retained secretions and bronchitis. The temperature and pulse did not rise above 100°F. Peristalsis became normal within two days. The patient was able to take an ulcer diet without difficulty.

On the fifth postoperative day, shortly after the noon meal, the patient felt nauseated and vomited a small amount of food. He felt well otherwise until an hour later when he suddenly became very weak and complained of pressure in the epigastrium. A physician found the

of difficulty in breathing and no chest pain. Chest examination was not remarkable. Abdominal examination revealed some upper abdominal distention and tympany. Peristalsis was audible but diminished. There was no abdominal tenderness. The wound was inspected and was not remarkable except for some induration and serous discharge about the stay sutures. Examination of extremities was negative for evidence of phlebothrombosis. He was given morphine, plasma and oxygen. A Levin tube was passed. No evidence of gastric stasis was obtained.

Following the administration of 500 cc. of plasma the blood pressure rose to 90/60, but it fell again to a systolic pressure of 60 mm. of mercury in a very short time; 500 cc. of citrated blood were given and again the pressure rose only to fall as soon as the blood had run in. These findings and the increasing pallor made it apparent that the patient was bleeding. It was believed that a co-existing posterior duodenal ulcer was the most probable source of the hemorrhage. Because of the uncertainty of diagnosis, the patient's recent surgery, bronchitis, and foremost of all, his alarming condition, it was believed that surgical intervention was not indicated. It was decided to rely on repeated transfusions until the patient's condition became stabilized.

During these early hours the patient remained conscious and rational. There presented no evidence of pulmonary embolus, massive collapse or coronary occlusion. An

electrocardiogram prior to surgery had been normal.

During the eighteen-hour period after the onset of this catastrophe, the patient required 6 liters of blood to maintain a pressure of 80/50. Any attempt to reduce the amount or speed of administration resulted in the blood pressure falling to an unobtainable level.

The day following the onset, signs of a high left diaphragm were noted with increased dullness corresponding to the left subphrenic space. The patient's general condition was improved. He was no longer clammy and cold and his condition appeared to have become stabilized. His abdomen was distended and peristalsis absent. No evidence of free fluid in the abdomen could be made out. There was no nausea or vomiting. He complained of slight fullness in the epigastrium. During the night he had spoken of an ache in his left shoulder.

In view of the large amount of blood he apparently had lost, the absence of hematemesis or blood in his rectum, it was thought that he may have been bleeding into the left subphrenic space from a ruptured spleen. He was questioned regarding trauma, malaria and other disorders but denied them all.

During the next four days he was given between 750 and 1,000 cc. of blood daily. His condition, appearance, blood pressure and pulse remained stabilized. His red blood count and hemoglobin rose slowly from 2.6 mil. and 65 per cent to above 4.0 mil. and to 90 per cent. His urinary output increased and his cough improved. He presented signs of a huge left subphrenic collection. However, his abdomen continued to show no evidence of free fluid. At the end of this time, his bowels moved several times and the stools showed no evidence of blood. X-rays of chest and abdomen revealed a very high left diaphragm and increased soft tissue density beneath the left diaphragm, and the splenic and transverse colon gas shadows were displaced downward. A diagnosis of ruptured spleen had been entertained and now was considered positive. The plan was to observe him carefully being ready to operate at once at the slightest suggestion of further bleeding. It was considered that every additional day of preparation would permit the patient's general condition to improve.

On the sixth day following his collapse, fall in blood pressure to 80 mm. of mercury and sudden perspiration indicated that further

bleeding was probably taking place. Accordingly, preparations for immediate operation were made. Intravenous needles were placed in an ankle and an arm vein and administration of citrated blood and plasma was started. Spinal anesthesia, 100 mg. metycaine, was given.

The abdomen was opened through a left rectus muscle splitting incision. A small amount of free blood was seen in the peritoneal cavity. The omentum and transverse colon were found tamponading a huge collection of blood in the left subphrenic space. It was estimated that 8 liters of blood and clots were present. This was removed by mopping and suction. A ruptured spleen was removed.

Postoperative convalescence was smooth and without incident except for moderate infection in the right abdominal wound.

The patient received 12 liters of blood in all without reaction. He has remained well to date. Careful investigation has failed to reveal any history of trauma, illness, or any evidence of blood dyscrasia.

Examination of the spleen revealed it to be of normal size. There was widespread elevation of the capsule from the spleen proper with old clot present beneath the capsule. A one-inch laceration of the right superior posterior border was present. No organized clot was noted. Microscopically, the architecture was preserved and the follicles were solidly normal in appearance. The central arterioles showed a moderate degree of mural thickening. The pulp was markedly cellular and the sinusoids contained a variety of nucleated cells including eosinophiles, polymorphonuclears, lymphocytes, and monocytes, and there was prominence of littoral cells. There were occasional mitotic figures. The pathologist stated that the histologic appearance of the spleen was not conducive to a definite diagnosis. His diagnosis was: (1) Hyperplasia of splenic pulp; (2) laceration of spleen.

COMMENT

The pathological anatomy of delayed splenic rupture has been well described. Two types of situations may be obtained. In one a perisplenic hematoma together with omentum may stop the bleeding before a serious loss of blood occurs. At a later date, softening of the splenic pulp

along with liquefaction of the hematoma permits sudden severe hemorrhage. In this type of case the latent period is usually marked by epigastric distress, nausea, dull pain in the left upper quadrant, left shoulder pain, diarrhea and weakness. In the second type, injury gives rise to a subcapsular hematoma which enlarges until the tension is sufficient to create a rupture of the capsule with a resultant sudden severe hemorrhage. In the presence of a subcapsular hematoma, the softness and vascularity of the spleen brings about a progressive lesion. Consequently, when the capsule ruptures, the soft pulp of the spleen gives rise to fresh rapid bleeding. The subcapsular fracture which originally caused the hematoma has been enlarged by the hematoma and it appears at time of surgery as a definite rupture. This type of case may have no symptoms whatsoever during the latent period and the injury may have passed from the patient's memory. The patients are reported, then, with sudden onset of symptoms without the slightest warning.

In Case I, during convalescence a history of falls on the ice as occurred every winter, was obtained, though no definite incident or injury to chest or abdomen could be recalled. It is entirely probable that a subcapsular hematoma occurred at the time of one of these falls.

In Case II, no injury of any sort was ever recalled. The patient had had some vomiting and cough prior to the perforation of the ulcer. After the operation for the perforation, the cough continued to a considerable degree. It is possible that the injury to the spleen may have occurred from this indirect violence, or the patient may have forgotten some direct trauma. An adhesive peritonitis about the spleen may have resulted from the perforated ulcer and the cough may have torn the capsule or spleen initiating a subcapsular hematoma. It is probable that spontaneous splenic rupture is the result of subcapsular hematoma following some slight and forgotten or unnoticed trauma. Since no

history of trauma was obtainable in these cases, they were to all practical purposes, spontaneous ruptures.

Diagnosis of splenic rupture may be fairly obvious or exceedingly difficult. Consideration of it as a possibility is a most important step. Kehr's sign, pain on top of the shoulder, is frequently present. Ballance's sign of shifting dullness in the right flank and dullness in the left flank which does not shift, may be present. Koucky has called attention, as have others, to the fact that fracture of the lower left ribs should put one on guard, for association of ruptured spleen and such fractures is not infrequent. X-ray examination may be very helpful. Upward displacement of the left diaphragm, displacement of the stomach to the right and the colon downward may be revealed, as well as increased soft tissue density in the left subphrenic space. Abdominal paracentesis may reveal blood or the blood may be loculated under the left diaphragm, thereby giving a negative tap. Abdominal tenderness and spasm centered in the left upper quadrant, evidence of hemorrhage, leukocytosis, and mild fever are common. The tenderness may be widespread with poor localization.

The two reported cases, and others in the literature indicate that the clinical picture may be predominantly one of hemorrhage or one of spreading peritonitis. Patients have been operated upon for acute appendicitis and perforated ulcer.

Since varying degrees of trauma are constantly being sustained, it is important to consider splenic rupture in any case which presents evidence of concealed hemorrhage or an atypical acute condition of the abdomen. A negative history regarding trauma does not rule it out.

SUMMARY

Two cases of rupture of the normal spleen occurring without definite history of trauma are reported.

So-called spontaneous splenic rupture probably results from a subcapsular hema-

toma following forgotten or unnoticed injury.

The importance of bearing this possibility in mind is pointed out, in view of high frequency of trauma in the present day. Particularly it should be watched for in patients receiving other more apparent and serious injuries.

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AVULSION INJURIES INCLUDING TWO CASES OF AVULSION OF THE SCALP*

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THE treatment of complete avulsion injuries involving the skin frequently can be carried out by using the avulsed skin to cover the defect. This becomes important when large defects are present such as the scalp. The only alternative to this method of treatment is the application of skin grafts; however, the principle is the same as the avulsed skin is converted to a fine thickness graft before being reappplied.

The method of treatment consists in recovering the avulsed skin as soon after the accident as is possible. It should be handled very gently to prevent further trauma and kept moist to prevent drying. A cool solution of physiological saline is used advantageously upon entry to the hospital to keep the skin moist. In conveying the skin to the hospital sterile gauze that is moistened can be used. We believe that cooling decreases the metabolism and thereby increases the time of viability. This concurs with the opinion of Brooks and Duncan¹ that lower temperature increases the survival time of anemic tissue. The avulsed skin is then examined and the extent of trauma is determined. If the skin is crushed, white and devitalized, it cannot be used. However, if the skin appears healthy and viable, it is then prepared for covering the defect.

The preparation of the skin is all important and the success of this method of treatment is entirely dependent upon the thoroughness with which this step is carried out. The subcutaneous fat and tissue are meticulously removed from the skin. This is performed with a razor or sharp scalpel using sharp dissection. It

is very important that all fat and subcutaneous tissue be removed so that the derma is exposed. The skin is kept moist and cool with the physiological saline during this procedure. After this the skin is ready to be transferred to the avulsed surface. The traumatized area is prepared by débridement and cleansing with physiological saline. All bleeding is controlled and any devitalized or necrotic tissue is removed so that a good base is made to apply to the skin. The skin is then sutured over the traumatized area in the same manner as a full thickness graft. The skin may require trimming to conform to the contour of the defect and must be made to fit snugly without overdue tension. This method of preparing the skin has been described by E. L. Keyes,² Alfred W. Farmer,³ and P. H. Jayes.⁴

CASE REPORTS

CASE I. Mrs. L. M. T. was admitted to the hospital by ambulance on May 11, 1943, at 8:30 A.M. She gave a history that while at work her hair became entangled in a fly wheel and tore off her scalp. Examination revealed a total avulsion of the scalp including the right eyebrow and upper half of the right auricle. There was also an extensive laceration just lateral to the left eye that extended down to the zygoma with considerable undermining of this area. The police were sent to retrieve the scalp and returned in an amazingly short time with the coveted missing part. Upon examination the scalp was found to be intact and in good condition except for one area on top which was torn and crushed. The viability of this area seemed doubtful to us. The weather man offered a damp day so there was little dryness to the scalp. The patient's general condition was good so she was

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taken to surgery. The scalp was moistened with cool physiological saline and kept so. Preparation of the scalp was first started by placing it

excised to make the scalp fit snugly. On the forty-fourth day split thickness grafts were taken from the right thigh and sutured in place



FIG. 1. Case 1. The scalp as it was retrieved by the police.

over an inverted bowl and shaving all the hair. Following this it was inverted and the preparation completed by removing all fat and subcutaneous tissue down to the derma. Due to the large area this preparation required two hours and ten minutes. All the time the scalp was kept at a lowered temperature by irrigating with cool physiological saline. The head was prepared by removing all dirt with soap and water. Bleeding was controlled and all devitalized and necrotic tissue excised and the whole area irrigated with physiological saline. The scalp was then sutured into its anatomical position around the borders. It was then discovered that the removal of the subcutaneous tissue prevented its snug fit. In order to remedy this two triangular areas were cut out on top and these were sutured in a straight line. This afforded a snug fit and a grease gauze dressing was applied.

The patient made an uneventful recovery and after forty-four days most of the scalp remained viable although an area on top of the head sloughed off. This corresponded to the area that was macerated and also to the area

on top of the head. She made an uneventful recovery and after about seventy days was ready for a transformation. It is of interest to note that the right eyebrow grew back and also some hair on the sides but none on the top. The skin over the scalp was soft and pliable. The recovery was entirely uneventful and she has an excellent cosmetic result.

CASE 11. Miss M. E., age twenty, entered the hospital July 12, 1944, with a history that her hair became caught in some large rollers and pulled off most of her scalp. Examination revealed an avulsion of most of her scalp and forehead. In one area the periosteum was exposed. The police were dispatched and retrieved the scalp. The scalp was found to be intact with only some maceration on the top. The patient's general condition was good so she was taken to surgery. The same procedure was followed as in Case 1. The scalp was kept cool with physiological saline and the hair shaved off. Then all the fat and subcutaneous tissue was removed by sharp dissection to the derma. It was then sutured in place and adjustments

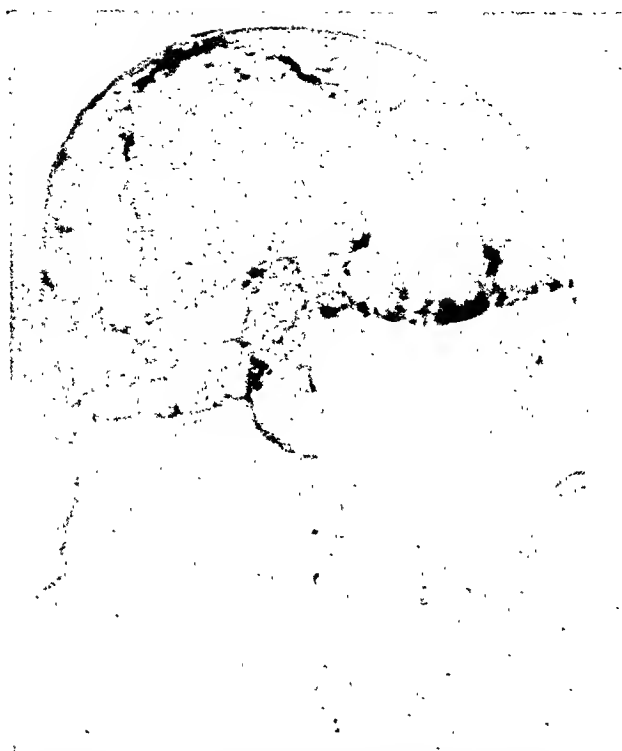


FIG. 2. Case 1. Appearance at first dressing five days after accident. Note loss of upper half of right auricle.



FIG. 3. Case 1. Fifth day after accident showing front view.

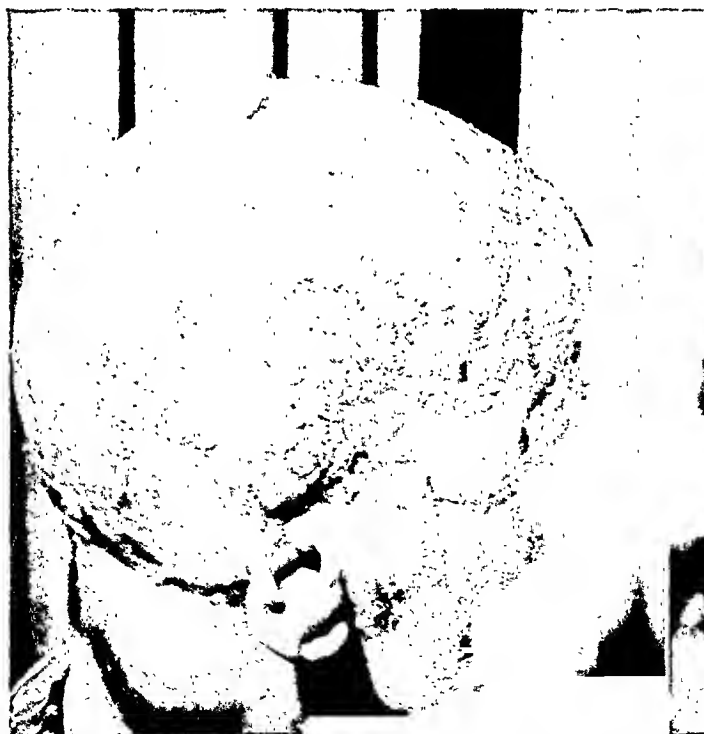


FIG. 4. Case 1. Forty-four days after accident showing the amount of scalp remaining viable.



FIG. 5. Case 1. Front view showing end result.

made to have a snug fit. A grease gauze dressing was applied.

The patient made an uneventful recovery and by August 16, 1944, most of the scalp was

the skin of the finger which they did. They found the skin on a clean piece of paper where his fellow workers had thoughtfully placed it. On arrival at the hospital, the skin was trans-



FIG. 6. Back view showing end result.

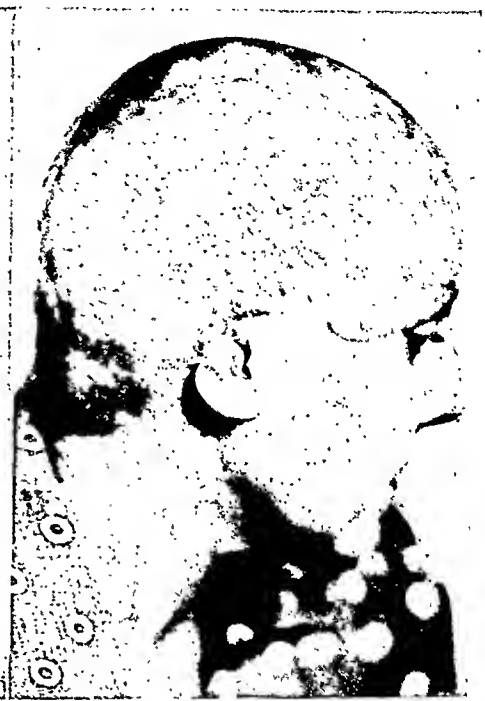


FIG. 7. Case 1. End result as viewed from right side.

viable except on the top which sloughed. On August 16, 1944, an attempt was made to skin graft the remaining area but before the operation was completed the patient went into shock and had respiratory difficulty and the operation was not completed satisfactorily. On September 16, 1944, another operation was performed and the remaining area which was small was covered with split thickness grafts. She made an uneventful recovery and was discharged from the hospital September 30, 1944. One small area on the top did not heal over and on November 18, 1944, another small split thickness graft was placed on this area. Following that the scalp was all healed. She has an excellent cosmetic result. No hair grew out and she wears a transformation.

CASE III. Mr. A. M., age fifty-two, entered the hospital May 21, 1943, on the service of Dr. E. L. Keyes with a history that about 8.00 A.M. he playfully pushed his way with some comrade through a door. The door slammed onto his index finger leaving the skin stuck to the door frame. The police were dispatched to retrieve

ferred to a sterile basin containing physiological saline at room temperature. The skin which of course was completely avulsed contained fat on its deeper surface. It measured 1.1 by 1.1 cm. The tip of the finger was clean with the phalanx visible in the wound with its periosteum unruptured and intact. Someone unknowingly placed some contaminated sulfanilamide powder on the tip. The skin was prepared by excising all the subcutaneous tissue, fat and blood vessels with sharp dissection. Then with clean instruments a débridement of the base of the finger was performed and all sulfanilamide removed. Hemostasis was controlled by gentle pressure with a wet sponge on the base of the wound. The avulsed skin was placed on its base with fingerprints running back into the normal parts. It was sutured with black silk. In one week all sutures were removed and on June 14, 1943, desquamation was present but the pores remained viable. On June 28, 1943, there was a loss of 3 mm. but no pores and the entire area was healed. The final result was a well functioning finger.

CASE IV. O. L. A., a ten-year old white male, entered the hospital on the night of November 22, 1943, with a history of having

the periosteum was exposed beneath the prepatellar bursa. There was no active bleeding. The avulsed tissue was left at the scene of the

FIG. 8.



FIG. 9.

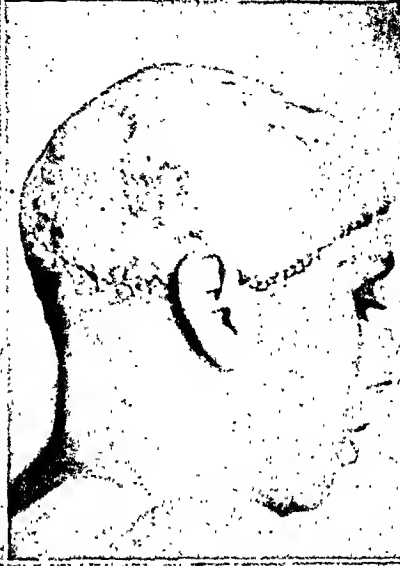


FIG. 10.



FIG. 11.



FIG. 8. Case 11. Fifth day after accident as viewed from the front.

FIG. 9. Case 11. Fifth day after accident as viewed from right side.

FIG. 10. Case 11. End result as viewed from the front.

FIG. 11. Case 11. End result with patient wearing a transformation.

been pushed through a store window thirty minutes previously. Examination at that time was essentially negative except for immediate trauma. There was a small abrasion of the upper lip and also a laceration about one-half inch in length at the angle of the left scapula. The right knee had a laceration on its medial aspect one and one-half inches in length and parallel to the upper border of the patella. This had partially severed the quadriceps femoris tendon. There was also an area two and one-half by three inches in diameter just over the lower half of the patella from which the skin had been completely avulsed. The deep fascia was exposed and in the upper edge of the wound

accident. Police retrieved the tissue finding it on the sidewalk at the base of the window (it was raining). In the operating room and under local anesthesia the tendon and laceration were sutured by Dr. Wiege, resident surgeon. The site of the avulsion was cleansed thoroughly with soap and water. The avulsed tissue was prepared by removing all fat, fascia and subcutaneous tissue down to the derma. This was performed with sharp dissection. The avulsed skin was then sutured in its normal place with silk sutures. Vaseline gauze with sulfathiazole powder and a pressure dressing applied. A posterior cast from the thighs to the toes was applied. On the sixth postoperative day the

sutures were removed and the patient was discharged with a cast. The tissue grew in place and a good result was obtained with functioning skin.

LITERATURE

From a review of the literature it was found that avulsions of the scalp are very



FIG. 12. Case III. This shows the traumatized finger and the loss of tissue.



FIG. 13. Case III. The avulsed tissue and showing the method of preparing the skin.

CASE V. Mr. R. F. entered the hospital on July 16, 1943, with a history of trimming corn with a knife at a market and cutting off the distal end of his right index finger. Examination

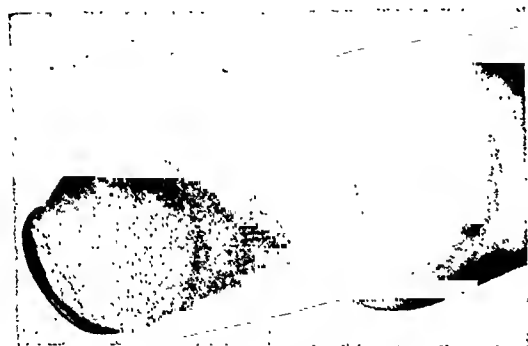


FIG. 14. Case III. End result showing the good functioning result.

revealed a complete avulsion of the tip of the finger on the volar surface 3 cm. in length. Dr. Mitchel Johnson, resident surgeon, then prepared the avulsed tissue by removing all fat and subcutaneous tissue down to the derma. The traumatized area was cleansed with physiological saline and débrided. The skin was sutured in place with interrupted silk sutures and a vaseline gauze dressing applied. The sutures were removed on July 23, 1943, and on the twelfth postoperative day the dressing was removed. All of the tissue remained viable and the patient had a well functioning finger.

unusual. Cahill and Caufield,⁵ in 1938, made an extensive review of the literature and the various methods used in the application of grafts to the scalp. It was generally agreed that grafting of skin formed the most successful way of treating these cases. Davis,⁷ in 1911, reported that the scalp was replaced in one piece in twenty-one cases and in all but one case there was a total failure. According to Davis, in 1898 Malherbe reported a case of scalp avulsion in which the scalp was shaved and cleansed with sublimate solution (1:1000) and replaced with forty sutures. Eight drains were used. The scalp died, but was converted into a parchment like covering or dressing of skin adherent to the cranium, under which healing occurred without complications. In 1922, McWilliams⁶ stated that he found forty cases in the literature in which the scalp had been replaced and in not a single instance did the scalp live.

In 1938, Alfred W. Farmer reported four cases of skin avulsion in which the skin was prepared like full thickness grafts and replaced. He states that this type of repair gives a better result than can be obtained with partial thickness grafts applied at a later date.

P. H. Jayes, in 1942, recorded a case in which a large area of skin was avulsed from a boy's thigh. The skin was repaired in the manner described and replaced. He obtained an excellent result.

E. L. Keyes, in 1942, reported a case in which the skin from the dorsum of the middle phalanx of a finger was completely avulsed. This was prepared and replaced and a remarkable result was obtained with a complete take of the skin.

COMMENTS

There are advantages in replacing avulsed skin in certain cases. It is a procedure which is not complicated and can be performed by surgeons that are not skilled in skin grafting. In the replacement of the scalp in Case 1, it is of interest to note that the eyebrow grew out and a little hair although the amount of hair was so small necessitating the patient to wear a transformation. Another advantage is that it saves damaged tissue and skin from certain death. If all of the avulsed skin does not remain viable, the area to be skin grafted later is smaller. It has also been found that

replaced skin is useable. This is exemplified by the finger tips which were replaced.

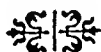
CONCLUSION

1. Two cases of avulsions of the scalp are presented and the method of treatment is discussed.

2. Replacement of avulsed skin can be used to advantage by properly preparing the skin as a primary treatment for wounds in which a loss of tissue is evident.

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BILATERAL RECURRENT INTERCARPAL SUBLUXATION

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ONE of the unusual causes for painful snapping or clicking of the wrist is a recurrent subluxation in the intercarpal region.¹ We recently encountered two such instances, in each of whom the condition was bilateral and was not the result of trauma. In these two cases the subluxation was repeatedly produced by strong active flexion of the fingers or hands. While the "snap" was one of the chief complaints, swelling and weakness of the wrists were also frequent complications. In the two following cases, clinical and radiographic findings as well as a follow-up of a surgical procedure are presented.

CASE REPORTS

CASE 1. A male, aged twenty, had complained of recurrent pain, swelling and clicking of the left wrist for the past three years without suffering any recent or previous trauma to this part. The patient stated that whenever he attempted to make full use of his left hand as in the performance of his routine duties, an audible click was produced in the left wrist. This had occurred several times a day and was complicated by the presence of pain and swelling in the wrist. In spite of the patient's precaution to avoid these clicks, the swelling and pain had become progressively worse. On the right hand, the click was first noted one year before. Since then it had recurred infrequently. The patient could not ascribe any definite cause for the onset of the symptoms in the right or left wrists.

Examination of the left wrist showed that the landmarks were normal except for a fullness in the "snuffbox" at the base of the metacarpal bone of the thumb. Strong active contraction of the flexor tendons of the fingers or hand caused the left hand to be temporarily displaced in a palmar and radial plane. This had produced an abnormal concavity on the dorsum of the left wrist. When this maneuver was performed, a loud click was produced in the

wrist which could be heard clearly for a distance of about fifteen feet. This sound, but of a lesser intensity, could be readily reproduced by passive anterior translocation of the hand or by passive palmar flexion and traction of the hand. Frequent repetition of this test caused an increase in the effusion in the carpal area. The concavity on the dorsum of the wrist could be easily obliterated by replacing the hand into a normal alignment with the forearm. No hypermobility was noted in the distal radioulnar articulation. The range of passive dorsiflexion of the left hand was 60 degrees, 10 degrees less than that of the right hand. The greatest angle of passive palmar flexion of the left hand was 120 degrees, equal to that of the right. The power of the left hand, however, was approximately 25 per cent less than that of the right. An abnormal concavity on the dorsum of the right wrist as well as a click could be produced on active contraction of the flexor apparatus of the fingers or hand or by passive manipulation of the hand. Subsequent to such repeated manipulations, the right carpal region became mildly enlarged and tender to touch.

Radiographic examination made of both wrists in the neutral and dorsi and palmar flexed attitudes of the hands revealed that the carpal and metacarpal bones were normal in appearance. It was noted that when the "click" was produced by active flexion of the fingers or hand, the distal row of carpal bones and the contiguous metacarpal bones were partly subluxed toward the palmar aspect. In these radiographs one clearly observed that the convex surface of the lunate bone was partly rotated towards the dorsum and that the anteriorly displaced capitate bone was in a plane parallel to that of the metacarpal bones. (Fig. 1.) The subluxation in the intercarpal region was not fixed and could be corrected easily by manipulation as was observed by fluoroscopic examination of the wrists.

In spite of one year of conservative therapy which consisted mainly of temporary im-

mobilization and muscle training of the left hand and wrist, one observed that the subluxations in the left wrist had occurred more

chondral zones. Slivers which were removed from the capitate bone were inserted into the joint space between the capitate, navicular, and



FIG. 1. A, radiograph of lateral view of left wrist with hand in neutral attitude. In diagram, L is the lunate bone, and C is the capitate. B, radiograph of lateral view of same wrist, taken as the click is produced by strong active contraction of the flexor apparatus of the fingers or hand. Note the anterior subluxation of the capitate bone and attached metacarpal bones. The convex surface of the lunate bone is rotated towards the dorsum. In diagram, L is the lunate bone, and C is the capitate bone.

frequently and were accompanied by increasing pain and local effusion. Because of these complaints an arthrodesis was performed between the left capitate, navicular and lunate bones. Under brachial plexus block anesthesia, a horizontal incision was made from the region of the styloid of the radius to the capitate bone on the dorsal aspect of the left wrist. The common extensor tendons of the fingers and those of the thumb and the dorsal branch of the radial nerve were exposed and retracted. The dorsal ligament was cut in a cruciate fashion and the navicular, lunate and capitate bones were brought into view. By flexing the hand and applying slight traction towards the palmar surface, a palmar subluxation of the distal row of the carpal bones and of the contiguous metacarpal bones was seen. This subluxation caused a temporary fore-shortening in the length of the carpal region. Reposition of the carpal bones into normal alignment was done with great ease. The articular cartilages of the opposing surfaces of the navicular, lunate and capitate bones which were dull and fibrillated were resected in order to expose their sub-

lunate bones. The dorsal ligaments were coapted and the extensor tendons were replaced into their respective tendon sheaths. The subcutaneous tissue and skin were closed with catgut and silk, respectively. The left hand and forearm were immobilized in a plaster of paris bandage for a period of three months. The hand was held in an attitude of 20 degrees of dorsiflexion. Radiographic examination made three months after the operation revealed beginning fusion of the capitate, navicular and lunate bones. Subsequently on removal of the plaster of paris bandage, a three month course of hydrotherapy and exercises was given to the entire left upper extremity to strengthen the muscles of the forearm. It was noted that the arthrodesis had resulted in a diminution in the range of dorsi and palmar flexion and of radial and ulnar deviation of the left hand. This hand could now be actively and passively dorsiflexed through an arc of 15 degrees and palmar flexed through an arc of 35 degrees. Follow-up examination one year after the operation showed that the patient had been able to make full use of his

left hand without experiencing pain, clicking, or swelling of the wrist.

Radiographic examination made six months and repeated one year after the operation

dorsum of the wrists. Radiographic examination of the right and left wrists and hands made as the click was heard revealed a bilateral anterior partial subluxation of the distal row of



FIG. 2. Radiographs of left wrist taken six months after the intercarpal arthrodesis. Note the obliteration of the joint spaces between the capitate, navicular and lunate bones.

revealed that a fusion had occurred between the left capitate, navicular, and lunate bones. (Fig. 2.) No subluxation was present in the intercarpal region either on active or passive palmar or dorsiflexion of the left hand or on active flexion of the fingers.

Recently this patient had requested that a similar operation be performed on the right wrist, but because of the infrequent occurrence of the click and subluxation on this side, surgical treatment was not advised.

CASE 11. A male, aged twenty-one, had complained of pain, swelling and clicking of the wrists, the right more frequently than the left, for the past eleven years without experiencing any antecedent or recent trauma to these parts. The click usually occurred during strong active contraction of the flexor apparatus of the fingers or hands. Because of the increasing number of episodes of swelling and pain in the right wrist, the patient sought medical advice.

On examination it was noted that the range of dorsi and palmar flexion of the hands was within normal limits. A click could be produced in either wrist by active flexion of the fingers or hands, by passive anterior translocation, or by passive palmar flexion and traction of either hand. When the click was produced a definite abnormal concavity was observed on the

carpal and contiguous metacarpal bones. The carpal and metacarpal bones were normal in appearance. The subluxations could be easily corrected by gentle manipulation. This patient was transferred to another military installation before treatment could be initiated.

COMMENT

As a basis for this investigation, we reviewed the radiographs of twelve pairs of normal wrists to observe the relationship of the carpal bones in the neutral, dorsi flexed and palmar flexed attitude of the hands. With the metacarpal bones in a strict neutral vertical attitude the lunate bone was not displaced dorsally or ventrally and the axis of the capitate bone was parallel to that of the metacarpal bones. On active palmar flexion of the hand, the capitate bone rotated almost to the horizontal plane towards the palmar surface while the lunate bone rotated exposing its convex surface towards the dorsum. On active dorsiflexion of the hand, the capitate bone was tilted toward the dorsum and the lunate bone was rotated exposing its convex surface towards the volar aspect. On

dorsi and palmar flexion of the hand, the navicular bone rotated in the same direction as the lunate bone.^{1,2,3} These studies revealed, first, the normal wide range of mobility in the intercarpal area, and second, the absence of any true intercarpal subluxation during normal movements of the hand.

In addition we examined clinically the wrists of 200 young male adults and we have noticed that minimal passive anterior translocation of the hand at the midcarpal region is a normal finding and that a faint click could be inconstantly produced by this maneuver. Furthermore, radiographic examination of the wrists of twelve patients in this group confirmed the clinical finding that minimal anterior subluxation of the distal carpal bones could be produced by passive anterior translocation of the hand. This indicated that the intercarpal ligament was normally long enough to permit passive minimal anterior displacement of the carpometacarpal unit. We also had an opportunity to examine clinically the wrists of ten adults with generalized lengthening of the capsular and ligamentous structures, hypermobility of the bones, in which moderate passive palmar translocation of the hands could be produced.⁵ Radiographs taken of these wrists as the hands were translocated showed a moderate palmar subluxation of the distal row of the carpal bones and attached metacarpal bones. In these instances the intercarpal ligament was "overlengthened" and readily yielded to the passive subluxation in the intercarpal region. Yet in the ten cases of generalized hypermobility of the bones as well as in the 200 normal ones, subluxation in the intercarpal region could not be initiated solely by active flexion of the fingers or hands. This suggested that in these cases the power of the flexor and extensor apparatus of the carpometacarpal unit was well balanced and prevented any intercarpal subluxation even in the presence of "overlengthened" ligaments.

On the other hand, it seems that in two

cases in question, there probably was a relative diminution in the power of the extensor mechanism which permitted the flexor muscles and tendons to pull the carpometacarpal unit out of alignment. Therefore, we believe that the basis for the subluxation is, first, an "overlength" of the intercarpal ligaments and, second, an imbalance in the power between the flexor and extensor apparatus of the fingers and hands.

CONCLUSION

Two patients with snapping or clicking of the wrists are described in each of whom pain and swelling of these parts were caused by a non-traumatic, recurrent palmar subluxation of the distal row of carpal and contiguous metacarpal bones. This was initiated by strong active flexion of the fingers or hands. In one of these cases, because of the frequent episodes of pain and effusion in the wrist, an arthrodesis was performed between the left capitate, lunate and navicular bones. This had resulted in a fusion of these three bones with complete disappearance of the click, pain and swelling of the left wrist.

It seems that the basis for the recurrent intercarpal subluxation may be a localized "overlength" of the ligaments binding the carpal bones and an imbalance in the power between the flexor and extensor apparatus of the fingers and hands. The loss of the normal check mechanism of these ligaments had permitted an anterior subluxation of the carpometacarpal unit by the pull of the unopposed flexor apparatus of the fingers or hands.

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EMBRYOMA OF THE KIDNEY (WILMS' TUMOR)

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WILMS' tumor, a distinctive new growth of the kidney, is second only to neuroblastoma sympatheticum as the most likely diagnosis in a child, between a few months and three years of age, with a hard, painless abdominal swelling. However, although it is essentially a childhood condition it is on rare occasions discovered in an adult. In view of the fact that the microscopic analysis of this neoplasm consistently reveals its mixed cellular nature and histological structure most clinicians believe that the proper nomenclature for the disease should be either mixed tumor or embryoma of the kidney rather than Wilms' tumor. Incidentally, as far as the sexes are concerned it shows neither favor nor disfavor being fairly equally distributed among males and females. Similarly, it has no predilection for either the left or the right kidney.

Pathologically, this new growth always originates but never remains within the kidney, since unrecognized, sooner or later with remarkable speed and progress, it stretches the capsule to the breaking point to be disseminated rapidly into the surrounding locality and between contiguous structures, continuing to the point of filling the entire flank and half the abdomen. Usually it has a firm, hard, rubbery feel to it through the abdominal wall, and although the surface appears smooth it not too uncommonly may be notched or lobulated so that momentarily it may be confused with a possible splenomegalia. Usually upon exposure at operation it becomes quite obvious that the kidney structure and contour has become markedly distorted not by immediate infiltration but by pressure. In our own case it was remarkably so since the neoplastic tissue had actually projected into and obliterated

completely the renal pelvis and had so invaded the hilum structures as to obstruct the lumen entirely of not only the renal vein, as is not uncommon, but the renal artery as well.

In the early stages of these cases and at a time when something really worthwhile could be done the clinical features are notoriously and characteristically absent. Unfortunately, not until it has gone through that insidious, treacherous silent state of development into a ready palpable, firm, painless mass or even eventually into a large tender painful swelling almost filling the entire flank is it usually recognized. Occasionally, as in the author's case, although the child may be fussy, pale, and "off its feeding" for several days (thought to be due to "teething," etc.) the enormous proportions the growth may reach before recognition are almost uncanny. Here it was in the process of a more or less cursory examination given prior to a contemplated inoculation for diphtheria and pertussis that a firm though tender mass was discovered projecting from beneath the left costal margin and bulging the left flank. With a systematic history one may casually obtain the information that for some little time the child may have gradually appeared pale, has been periodically feverish, and the urine has been occasionally "sort of rusty."

Nothing very conclusive nor convincing is derived particularly from the laboratory except from the x-ray studies; the flat plate of the abdomen usually reveals a ground glass appearance, a more or less opaque shadow, in one or the other flanks with a concomitant medial displacement of the bowel gas shadows. Pyelograms are useful; although rarely required for diagnosis, they are instructive; for, they not only may evalu-

ate the function and display outline of the other kidney but may aid the surgeon in mentally outlining his approach to the technical problems of its excision and hoped for extirpation.

Rarely in the realms of medicine and surgery is a condition so obvious that it requires no differential consideration, and the embryoma of the kidney is no exception. First and foremost in passing should be considered the previously mentioned *sympathetic neuroblastoma*, found in slightly greater frequency among similar age groups; it is highly malignant and metastasizes early. Although firm, with poorly defined borders, it is usually smaller and has more pebbly or finely nodular surface. Next from the point of view of frequency is the *hydronephrosis* which with its own characteristics and especially the pyelograms can readily be differentiated.

Tumors and enlargements of liver and spleen especially of the latter as well as *visceral tumors* must likewise be kept in mind. The *hypernephroma* so common as a tumor of the kidney in adults need hardly be considered here because of its absence in childhood. Tragic to relate, but by and large, the diagnosis is not usually a difficult problem, since by the time the physical examination of the child is sought the characteristic abdominal mass is altogether too self-evident and beyond the domain of a favorable prognosis.

All patients left untreated die; most patients even if treated die. Nevertheless irrespective of size as long as there is no evidence of metastasis elsewhere Ladd states "surgical excision holds the only hope" and should be carried out without delay, without preoperative irradiation. Most clinicians universally are not in full agreement with this dictum but prefer to procrastinate long enough to accomplish some shrinkage of the mass with preoperative irradiation. For no specific reason in the case herewith presented we chose to follow Ladd's assertion and operate without previous radiation on what proved to be a hopeless proposition in which the

renal pedicle and vessels were so choked with neoplastic tissue that the clamps could be removed from the unligated stumps without the slightest semblance of even a bloody ooze.

CASE REPORT

L. T., a seven months' old white female of polish extraction, was born at the Lowell General Hospital prematurely at about seven months' gestation on February 15, 1944, weighing four pounds and twelve ounces. She gained steadily on breast milk, was brought to the Hospital religiously and conscientiously daily by the mother and was finally discharged on February 22, 1944, weighing six pounds; up to the present time she had developed normally. She was readmitted to the Children's Ward of the Lowell General Hospital on October 9, 1944, at the age of seven months with a temperature of 102.6 F., a swollen abdomen and a mass in the left side and flank which had been noted during a cursory examination. At the time the mother stated that the child had been fussy and fretful for the past week or so and of late did not want to be bathed; she had been a little feverish too but thought that it was due to teething, especially, when for the last few days she had begun to refuse her food, even the bottle. The bowels had been normal and except for wetting frequently she had noticed nothing unusual about the urine, except that when asked specifically about any change in color she believed that at times it had been "sort of rusty."

A thorough physical examination revealed negative findings in general with the exception of a most marked palor almost of a waxy nature, feverish and fretful, restlessness associated with a tearless whining cry. One middle incisor tooth had just made its appearance. The chest, heart, and lungs were normal.

The abdomen was round, full and markedly distended, more or less hard, firm, and tender throughout although not board-like; however, between respirations it appeared moderately softened especially on the right side. On the left side there still appeared to be some spasm and rigidity with a suggestive readily outlined mass in the entire left flank over which there was considerable tenderness to both superficial and deep palpation. The left flank definitely seemed to bulge and had a solid feel to it. Rectal examination was noncontributory; all reflexes

were active. On October 10th, hemoglobin was 70 per cent; red blood cells, 4,410,000; white blood cells 16,100 with a normal differential, the following day the hemoglobin was 62 per cent; red blood cells 3,920,000; white blood cells 12,300. Coagulation time was three minutes, and bleeding time two minutes. The red blood count appeared slightly achromic and polychromatic. Her blood type was Type O.

Urinalysis showed the urine to be acid; specific gravity 1:020; a slight positive trace of albumin but no red blood cells; pus cells were rare; crystals were seen; and the patch test for tuberculosis was negative. X-rays of the chest showed lung fields clear and heart shadow normal; but the heart pushed up by a diaphragm which was high from what suggested distention in the abdominal cavity.

On October 11, 1944, a report on an x-ray of the abdomen was as follows: "There is a large homogeneous area of dullness on the left side displacing the colon towards the right. The appearance suggests a large left kidney."

On October 14, 1944, the report on an intravenous pyelogram stated: "The examination was not entirely satisfactory. However, some of the opaque solution was seen in the right kidney but none in the left. One of the films showed a large fusiform shadow in the bladder region, the nature of which is hard to determine. However, this probably represents the bladder shadow, the right side perhaps not being filled. The appearance suggests a tumor of the left kidney."

While the child was under care preoperatively with transfusions and intravenous solutions, etc., she began to have edema of the limbs and abdomen. However, on the morning of the operation although the pulse and respirations were rapid, her condition did not appear too badly. So after cutting down on the ankle vein for a phlebotomy in order to give a continuous transfusion during the operation, the patient was anesthetized with ether and a left rectus incision was made, splitting the rectus muscles to grasp and open the peritoneum through which there immediately protruded several loops of distended small bowel. With the small bowel walled off, the peritoneum along the left gutter and colon was incised so that the colon could be retracted well medially from the splenic flexure to the sigmoid. Rotating the colon medially thus exposed almost in its entirety a large tumor occupying all the peri-

renal area and extending to the pelvic brim, being as large as a child's toy football. With some difficulty the kidney and tumor was freed anteriorly and posteriorly but it was quite obvious that there was considerable metastatic glands around the renal vessels and pedicle extending retroperitoneally over to and along the spine. With the pedicle freed, clamps were placed about the renal vein and artery and then cut between. The artery was tied successfully but in attempting to tie the vein structures which were of a cheesy consistency the tie cut through them completely; however, there was absolutely no bleeding because the vein appeared to be clogged with metastatic malignant tissue. The ureter was exposed, cut and tied. The colon was resutured back into its gutter and the abdomen closed in layers in the usual fashion.

As the child was being lifted from the conveyor back to her bed she suddenly turned very cyanotic, coughed and choked a few times, gasped and expired before oxygen or anything else could be administered. No autopsy was obtained but it would appear very likely with our operative findings that some of that mass choked in the renal vein became dislodged and floated to the lungs as a massive metastatic pulmonary embolus.

SUMMARY

To summarize this subject of embryoma of the kidney which unfortunately carries such a poor prognosis, one usually has to deal with a somewhat pale, fretful, young child running a silent, painless, symptomless course finally coming for a check-up, or because of an accidentally discovered abdominal mass whose surface is smooth but nodular and extending one-half to two-thirds down one or other of the flanks. The differential diagnosis is briefly considered and the treatment of preoperative irradiation followed by surgical excision discussed.

An almost classical text book type of case is reported; however, the usually fatal outcome came a little more abruptly than was anticipated and was thought, because of the operative finding, to be due to massive metastatic pulmonary embolus. The treatment with no evidence of metastasis

is nephrectomy with or without preoperative irradiation, the latter still somewhat of a moot point

Embryoma of the kidney carries a grave prognosis, death within a few years at best.

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THE indications for nephrectomy are severe kidney trauma, tuberculosis, tumors, extensive chronic or acute infection with destruction of the kidney, large calculi which cannot be removed successfully without removal of the kidney, certain cases of ectopic kidney, and selected cases of hydronephrosis.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

DOUBLE GALLBLADDER*

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CONGENITAL anomalies of the gallbladder are uncommon. Boyden¹ found only two examples of double gallbladder in the reports of anatomical dissections of 9,221 cadavers collected from eleven American anatomical laboratories.

In a review of the literature only forty cases were found representing congenital reduplication of the gallbladder proven by autopsy or operation. Twenty-three of these cases occurred in females and eight in males. In nine cases the sex was not stated. Cases that were inadequately described, those discovered during x-ray examinations, and deformities which were obviously inflammatory in origin were purposely omitted from this study.

As a result of his study Boyden¹ classified this anomaly into two groups: The first, vesica divisa, or cleft gallbladder, is the result of division of the primary cystic diverticulum forming a partial reduplication of the organ with two cavities emptying into a common cystic duct. Externally these may appear with a cleft or a single fundus. In the latter, sagittal section of the vesicle reveals a longitudinal septum dividing the organ into two chambers. There were five reported cases of cleft gallbladder²⁻⁵ to which is added the example described in this report.

The second group, vesica duplex, is composed of those with two gallbladders and two cystic ducts. The accessory gallbladder arises from either the cystic, hepatic, or common bile duct. There were twenty-four examples of this group in the literature. These can be further subdivided into the Y-shaped type and the ductular type. In the former, the two gall-

bladders are usually bound together and occupy the same fossa of the liver. The two cystic ducts unite to form a common cystic duct which empties into the common bile duct. Eight of the cases were of this type.⁷⁻¹⁴

In the ductular type the cystic ducts empty separately into the common bile duct with the two organs attached to the same or different lobes of the liver. Sixteen cases of this type were reported in the literature.^{4,15-29}

There was insufficient description in eleven of the reported cases to place them in either of the above mentioned groups.³⁰⁻³⁹

CASE REPORT

D. L., C.H.H. No. 20361, a forty-two year old, white housewife, complaining of severe epigastric pain of twelve hours' duration, was admitted on August 29, 1941, to the Surgical Service of the Church Home and Hospital. The pain was constant and accompanied by nausea, vomiting and diarrhea.

The patient was an acutely ill, obese female with an admission temperature, pulse and respiratory rate of 98.6°F., 70, and 22, respectively. There were tenderness, rigidity, and rebound tenderness in the epigastrium and region of the gallbladder.

The white blood cell count was 11,700. There was a trace of albumin in the urine. X-ray examination of the gallbladder on September 2, 1941, following the oral administration of tetraiodophthalein showed that the gallbladder failed to concentrate the dye to normal intensity.

On September 5, 1941, the patient was operated upon under nitrous oxide-oxygen-ether anesthesia. An upper right rectus incision was made and the gallbladder located without difficulty. It was surrounded by adhesions which

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were readily separated. Lying beneath it was a cystic mass likewise covered by adhesions. Upon dissection of this mass another vesicle was exposed. The fundi were connected by a fibrous tissue band and there were a common ampulla and cystic duct. Both fundi with the ampulla and a portion of the cystic duct were removed.

The postoperative course was uneventful and uncomplicated and the patient was discharged from the hospital on the eighteenth postoperative day.

On pathological examination the gallbladder presented the unusual appearance of two distinct lobes, the larger measuring 7 by 2 cm. and the smaller 5 by 2 cm. These lobes united to form a common cystic duct of which a portion 8 mm. in length was present. (Fig. 1.) The external surfaces were rough and shaggy and the tissues congested and edematous. On opening the vesicles the mucosa was found to be well preserved in the larger lobe but was degenerated and eroded in the smaller one. Impacted in the base of the smaller lobe was an oval, "mulberry-type" gallstone measuring 12 by 15 mm. which was distinctly separated from the lumen of the larger lobe by a well developed septum. A similar, slightly larger stone and four smaller stones were found free in the fundus of this smaller lobe. Numerous similar stones ranging up to 12 mm. in diameter were found in the larger lobe.

Microscopic section of the fundi showed moderate edema and diffuse polymorphonuclear and lymphocytic cellular infiltration. There was a definite muscular layer in each lobe, the muscularis of the smaller lobe being thicker and more fibrotic. The mucosa of the larger lobe was relatively well preserved but in the smaller one there was considerable erosion with scattered areas of superficial necrosis and leucocytic infiltration. Sections showed the muscular walls of the two organs to be distinctly separated by loose fibrous tissue.

CONCLUSIONS

1. Congenital reduplication of the gallbladder is uncommon.
2. A review of the literature revealed forty cases of this anomaly.
3. The existing types of double gallbladder can be explained on an embryological basis.

4. A case of vesica divisa or bilobed gallbladder is described.

The author is indebted to Dr. Vernon Norwood for the pathological study and report of this specimen.

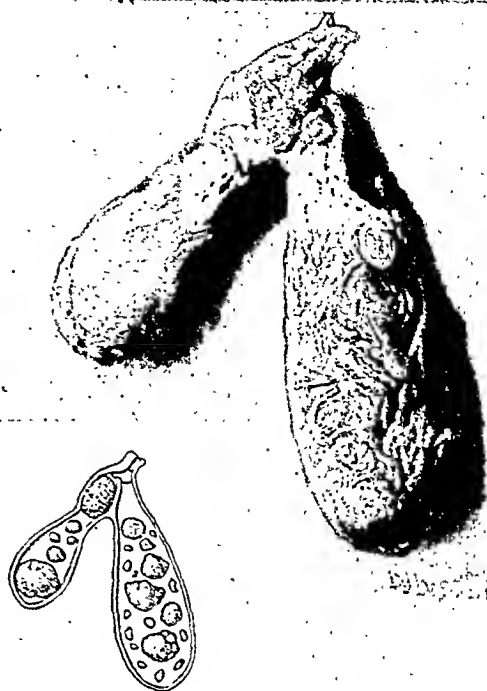


FIG. 1. Artist's drawing illustrating the bilobed gallbladder with small portion of the cystic duct attached. Insert shows the arrangement of the calculi within the vesicles.

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DUODENAL OBSTRUCTION COMPLICATING CHOLECYSTECTOMY

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THIS case from the Carson C. Peck Memorial Hospital, Brooklyn, is interesting from several view points which separately and collectively constitute departures from the usual: (1) The gallbladder was of distinctly hour-glass formation. (2) The postoperative course was marked by vomiting which persisted for fifty days; and (3) there was an abnormality of the duodenum, with enteritis of the duodenojejunal junction.

CASE REPORT

Cholecystectomy was performed six and one-half years before. The patient was an eighteen-year old female who for most of her life had intermittent attacks of vomiting lasting ten days or less.

Six months before operation she had an attack of excruciating right upper quadrant pain with vomiting and jaundice. Her past history revealed vomiting in the neonatal period, which was investigated by x-ray for hypertrophic pyloric stenosis. This condition, however, was not present. At the age of fourteen she had an adenoma of the thyroid removed following which she had no vomiting attacks for about one year. Physical examination six and one-half years before revealed a well nourished, well developed girl without abnormal physical findings. The gallbladder study by x-ray showed that the gallbladder did not fill and that there were no opaque calculi.

In early February, 1939, a cholecystectomy was performed under ether and cyclopropane anesthesia. There were no calculi palpated in the gallbladder or the biliary ducts. The gallbladder was normal except for its hour-glass formation.

The postoperative course was remarkable mostly because of continued vomiting. There was moderate upper abdominal distention, but the abdomen below the umbilicus was scaphoid and remained so. The bowels moved

first on the fourth postoperative day and continued to move throughout her prolonged hospital stay.

In the first twenty-three days after cholecystectomy, her temperature rose to 103°F. on two occasions. More often it was less than 100°F., at times going to 101°F. Her pulse was never over 120. Most of the time it was between 70 and 100. She continued to vomit. She had upper abdominal cramps. During this twenty-three-day period, the end of which was marked by a second laparotomy, she received many small transfusions to sustain her, plus infusions of Hartman's and Ringer's solution to supply the needed salts and fluids.

On the fourth day after cholecystectomy a Levine tube was passed into the stomach. This was done because the vomiting, which occurred two or three times each day, had not responded to infusions of glucose and saline or to the removal of the cigarette drain from Morrison's pouch and because there was some soft, upper abdominal distention. Through the Levine tube 1,000 cc. of dark, brown liquid was aspirated and following this, for a time, amounts such as 600 cc. were drawn through the tube. The tube was kept in the stomach because the dark brown fluid would repeatedly collect. Presently the returns became bile-stained, clearer and less putrid. After the stomach contents had assumed this improved character, the tube was clamped off for several hours at a time, but it was found that the stomach would repeatedly fill. The bowels continued to move, though in small amounts.

During this period aspirations of the stomach were effected by the use of Wangenstein suction. The stomach contents consisted of biliary and gastric juices, plus thin foods which the patient was allowed to take by mouth. These contents were sucked into a catch bottle and introduced into the rectum through a Harris drip.

On the twelfth postoperative day, a Miller-Abbott tube was substituted for the Levine tube.



FIG. 1. Balloon beyond pyloric sphincter.



FIG. 2. Barium in the stomach, some in duodenum and some in misplaced upper jejunum.



FIG. 3. Balloon seen in transverse duodenum one inch to right of midline.



FIG. 4. Great distention of first and second portions of duodenum with thin column of barium in the distal part of third portion terminating at the right of the spine.

X-ray studies were as follows: The first plate showed the tip of the tube in the stomach with some gastric dilatation, mostly due to gas. The following day a thin barium mixture was injected into the balloon and the location of it was found to be just beyond the pyloric sphincter. (Fig. 1.) The next day a barium solution was run down the open side of the Miller-Abbott tube. (Fig. 2.) X-ray showed some barium in the stomach, some about the tip of the tube in the duodenum, and some in the upper jejunum. The jejunum was seen to lie to the right instead of to the left of the spine. The next picture was taken twenty-four hours later; the balloon was seen in the transverse duodenum about one inch to the right of the mid-line. (Fig. 3.) A later x-ray study with more barium showed a great distention of the first and second portions of the duodenum with a thin zigzag column of barium in the distal part of the third portion, (Fig. 4) coursing downward to the right of the spine. These pictures led to the conclusion that a partial obstruction existed at the termination of the third portion of the duodenum, also that it was probably chronic as evidenced by the tremendous distention and elongation of the proximal duodenum. (Figs. 5, 6 and 7.)

Clinically, she was becoming progressively worse. There was a steady advance in emaciation and the advent of irregular twitchings of hands, feet and face, which were interpreted as tetanic. These were treated with calcium gluconate and she responded well.

Another complication was bleeding from the stomach, which may have been due to extended intubation. This complication was met with the administration of amphogel and the bleeding stopped.

Having established that the obstruction was not complete, a so-called duodenal or pre-digested feeding was given through the tube for the benefit which might accrue from that portion which passed the obstruction. In the presence of her semi-starvation, attention was paid to vitamin therapy, especially administration of B₁. If the stomach was not emptied at regular intervals, the patient would vomit unfailingly.

Therefore, on the twenty-fourth day post-operatively, a laparotomy was performed with the intention of relieving the obstruction or performing a duodenojejunostomy. A right-sided, paramedian, upper abdominal incision

was made. Extensive adhesions were found between the stomach and transverse colon to the anterior abdominal wall. These were



FIG. 5. Dilated stomach and distended duodenum.

separated at the expense of considerable time. Ultimately the viscera were freed sufficiently to evaluate the pathological condition at the distal duodenum. The proximal duodenum was found to be greatly distended, its wall so thin as to make apparent the Miller-Abbott tube still *in situ*. This portion of the duodenum was supplied with a mesentery long enough to allow it to be brought up to the level of the anterior abdominal wall. The duodenum was followed downward in the abdomen where it was fastened at a point to the right of the spine for a distance of two inches. It presented the following condition: It was indurated and fixed; there was loss of serosal luster; the serosa was injected and speckled with minute reddish, punctate areas; there was no exudate; the jejunum beyond was normal and collapsed; the superior mesenteric artery did not pass anterior to the duodenum.

By this time the patient was in exceedingly poor condition and further surgery was abandoned. The abdomen was closed with through and through sutures.

Her reaction was stormy for two days, following which she quieted down. Renewed efforts were made to sustain her with transfusions, parenteral fluids and salts. Gradually

her gastric retention became less and less. She gained strength slowly and was fed by mouth with the tube in the stomach as a

half years have elapsed since her discharge from the hospital. She quickly became strong and robust and has remained so.



FIG. 6. Barium shown in duodenum terminating to right of spine; beginning jejunum lying completely to the right of spine.



FIG. 7. Barium in stomach, and dilated duodenum; jejunum lies to right of spine.

safety valve. On the fourteenth day after the second operation, retention was small enough to warrant removal of the Abbott tube.

During the remainder of her stay in the hospital she vomited from time to time and had repeated epigastric cramps. Her vital balance was now on the positive side. Slowly she gained weight and strength until on the fifty-seventh day in the hospital she was in satisfactory condition for discharge.

In the eleven months following the operation the patient gained forty-eight pounds and vomited once. Now approximately six and one-

CONCLUSIONS

1. The patient presents two congenital defects, first, the abnormal hour-glass gallbladder; secondly, the fault in the fixation of the duodenojejunal junction.

2. The duodenal fault has in no way been remedied.

3. The practice of doing a gastrointestinal x-ray in all conditions suggestive of gallbladder disease would in this case have been valuable.



OSTEOCHONDROMATOSIS OF THE ELBOW

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OSTEOCHONDROMATOSIS is a disorder of joints, bursae or tendon sheaths, characterised by formation of osteocartilaginous bodies arising, evidently, from synovial membranes. It appears to be a rare condition, as Böhm¹ and Bunne² mentioned only eighty cases reported in the literature. Of these, twenty-seven cases were found to occur in the knee joint and thirty-six cases in the elbow. Bursae were involved in two instances and tendon sheaths in three. Only three cases, all in the knee joint, were bilateral.

The etiology is obscure. The principal factors which are considered as causes are infection, trauma, embryologic maldevelopment and neoplasia. Although infection may be excluded with reasonable certainty, there is considerable difference of opinion, from the discussions of Böhm¹ and Rixford³ regarding the relative importance of the remaining factors.

From the standpoint of pathogenesis it is generally accepted that the osteocartilaginous bodies, varying greatly in size, number and location, are derived from synovial tissues and may exist for indefinite periods of time within the joint space, either in attachment to the synovium or as free bodies. It is also agreed that varying degrees of synovitis may develop in connection with the formation of these structures.

The clinical features, subjective and objective, depend on the number, size and location of the osteocartilaginous formations. According to Wilmoth,⁴ who reported nine cases, the general subjective symptoms are those usually complained of in arthritic joints. Among objective manifestations, palpation of the loose bodies within the joint cavity is the most important finding and the diagnosis is confirmed by roent-

genographic study, by which an accurate appraisal of the extent of involvement is made possible.

Treatment consists of surgical removal of the osteocartilaginous structures and in addition it is in some cases necessary to undertake a partial synovectomy.

The prognosis, in general, is favorable with regard to restoration of function and recurrence is rarely, if ever, noted.

CASE REPORT

The patient was a white male, aged thirty-three, employed as a burner in a shipyard, and complaining of pain and loss of motion in his right elbow. Three days previously he slipped and fell on a steel plate, breaking the fall with his outstretched right hand. He noted no immediate ill effects except a mild discomfort in his right elbow. Two days after the fall, while reaching forward for an instrument, he felt a sudden sharp pain in the right elbow and found that motion in the joint was restricted due to pain. The pain became gradually more intense, being most pronounced over the outer aspect of the joint and radiating upward to the shoulder.

Examination of the elbow showed no obvious deformity or inflammation. Active motion was possible from 80 to 150 degrees. Beyond these ranges, motion caused pain on the lateral aspect of the joint. Pronation and supination of the forearm were approximately normal in range and painless. Posterolaterally over the elbow a swelling was noted, about one inch in diameter, somewhat irregular, slightly movable, firm, and tender on pressure or manipulation. No effusion was found in the joint. Mild tenderness was present also over the anterior and medial surfaces of the elbow.

Roentgenographic examination (Fig. 1) showed several small shadows within the joint space and situated between the upper end of the ulna and the head of the radius. Diagnosis: Osteochondromatosis.

Operation, undertaken six days after onset of symptoms, consisted of a posterolateral incision, splitting of the anconeus muscle, opening of the capsule and removal of three bony structures from the joint cavity. These bodies were attached to each other by fine strands of

cartilage and bone. There are also foci of amorphous calcareous material, suggesting calcified cartilage. Some portions of the pe-



FIG. 1. A, lateral and B, oblique views of elbow showing osteocartilaginous bodies situated between head of radius and upper end of ulna.

soft tissue, but were not attached to any portion of the capsule. About 15 cc. of straw-colored fluid escaped from the joint space. The synovial membrane, visible over a small area appeared normal. The wound was sutured in layers.

Pathologist's report: "Macroscopic: Three small pieces of bony tissue which are attached to each other by thin bands suggesting synovial membrane. The bony structures measure $13 \times 12 \times 8$ to 17 millimeters in extent. On section they consist of friable calcareous tissue. The outer surface is somewhat irregular and for the most part covered by the membranous tissue which forms the connection between the fragments.

"Microscopic section of one of the small pieces of bony tissue shows a structure composed of various stages in the development of

riphery show a highly cellular tissue but synovial membrane was not found.

"Diagnosis: Articular Osteochondromatosis."

Postoperatively a sling was used for support. The incision healed by primary union. Ten days after operation, a painful swelling with fluctuation appeared at the operative site. This was interpreted as a localized synovitis, for which roentgen therapy was administered on two different occasions. Postoperative roentgenograms showed no abnormality. The pain and swelling subsided, motion in the joint increased in range, and the man returned to light work twenty-four days after the operation. Eight weeks after operation he was performing his regular work. He stated that he had no pain in the elbow and that he "can do practically anything with it." The range of active motion at

this time was from 50 to 170 degrees. When he was seen five months after operation his only complaints were incomplete extension of the elbow and pain in the elbow when throwing a baseball. Active motion was present from 50 to 170 degrees. Pronation and supination of the forearm were normal in range and painless.

COMMENT

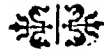
This case appears to be somewhat atypical from the standpoint of its acute onset, without previous indication of disability. The osteocartilaginous bodies undoubtedly had their origin for an indefinite period of time before manifestations appeared. The location from which these formations arose within the joint is also a matter of speculation, although it is likely that there had been very little shifting within the articular space.

SUMMARY

A case of osteochondromatosis of the elbow is reported with clinical, operative and pathologic findings. Postoperative observation over a period of five months showed practically complete return of function, the principal feature of disability being a 10-degree restriction of extension of the elbow.

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TAENIA SAGINATA IN THE APPENDIX

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THIS case of taenia saginata in the appendix is reported because it is a medical curiosity. Many cases of

The past history was essentially negative except for two pregnancies. Physical examination was essentially negative. Heart and lungs

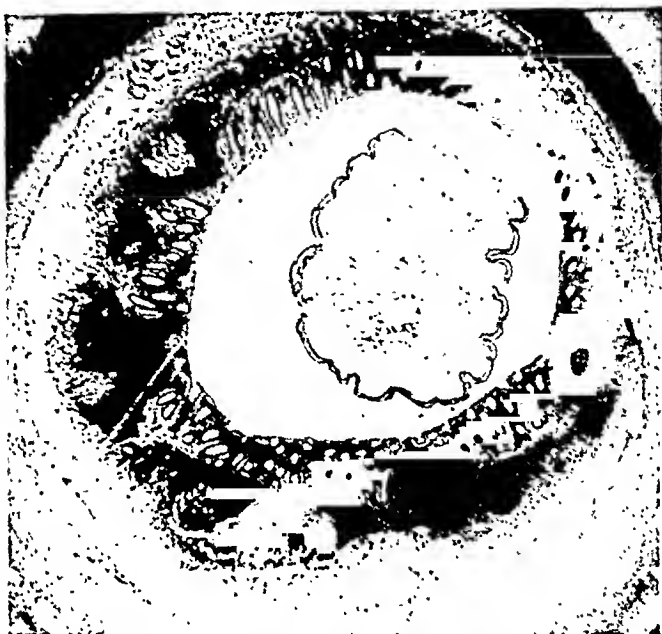


FIG. 1. Tapeworm in lumen. Note ova in the segment of the worm. Each proglottis has its own ovaries, uterus and testes.

foreign bodies in the appendix have been reported in the literature. Fowler, in a review of 10,095 cases of appendicitis, reported an incidence of 2.6 per cent due to foreign bodies. These cases contained calcified fecaliths, seeds, grain, pins, tooth-picks, gunshot, fish bones, pin worms, but no cases of taenia were reported.

CASE REPORT

On June 16, 1944, Mrs. A. T., a white woman, age twenty-three, complained of a dragging discomfort in the lower right quadrant. She gave a history of recurrent attacks of pain that lasted several hours but she did not get excited about her condition because the pain was not severe. However, lately the symptoms were becoming more severe causing her to consult a physician.

were normal. The abdomen was soft and there was no tenderness. The pelvic examination was negative. Urinalysis was negative. The red blood count was 3,800,000, white blood count 8,200, and her hemoglobin 82 per cent. A differential was not made but looking back on the case, an eosinophilia would have been a diagnostic point.

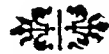
After several weeks the symptoms became more severe and a diagnosis of chronic obstructive appendicitis was made July 31, 1944. An appendectomy was performed through a right rectus incision. The appendix was edematous but rather disappointing in that it looked quite normal. When the pathological section came back, much to our surprise, the lumen of the appendix contained a tapeworm. The patient made a rapid recovery and on the sixth post-operative day was given male fern treatment

and passed a tapeworm (*taenia saginata*) twelve feet in length.

The patient made an uneventful recovery and is symptom free.

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AN unnecessary appendectomy should not be done during an abdominal or pelvic operation which probably will be followed by some oozing of blood into the peritoneal cavity. A sump drain is routinely advisable if there is a possibility of postoperative oozing both to indicate the presence and amount of oozing and to keep the cavity free from blood and exudate.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

PARASITIC FIBROIDS*

GIANT PARASITIC FIBROID WITH SARCOMATOUS DEGENERATION

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UTERINE fibromyoma constitute the most common pathological condition seen on the gynecological wards at Charity Hospital, about 750 operations being done for this condition here each year. Despite the high incidence of these tumors, complications are extremely rare, and over 95 per cent of these patients present themselves because of the palpable tumor or because of vaginal bleeding. Most complications are due to lack of blood supply and are in order: (1) edema, (2) necrosis with liquifaction, (3) mucoid degeneration, (4) calcification, (5) hyaline degeneration, and (6) red degeneration. Malignant degeneration occurs in less than one per cent of the cases and is usually picked up accidentally at pathological examination of the surgical specimen.

McFarland¹ gives a table with twenty-seven authors with statistics varying from 0.0 to 10 per cent, and quotes Albrecht as stating that there were 1.41 per cent malignant leiomyomas out of 77,076 fibroid specimens. Carl found an incidence of 0.22 per cent of 1,777 surgical cases at Memphis General Hospital. Complete cystic degeneration of a fibroid is very uncommon and only very few reports are in the recent literature. Most of the reports are in the early literature. Probably the rarity of the condition at the present time is due to the fact that in recent years diagnoses are made sufficiently early to prevent the development of huge cysts.

Wandering or parasitic fibroids are tumors which have separated from the uterus. They usually derive their blood supply from the omentum and are buried deeply in the pelvis. They occur much

more frequently than is usually suspected because so few of the cases seen are reported. Four parasitic fibroids have been removed from the pelvis in the last year at Charity Hospital during hysterectomy.

The following case report represents a complication of a uterine leiomyoma that has not been previously reported in medical literature:

CASE REPORT

E. M., a fifty-one year old colored female, was admitted to Charity Hospital for the first time June 21, 1944, with the chief complaint of a lump in the left side of her abdomen. For several years she had experienced an annoying but not severe pain in the lower left thorax, but which became severe especially with deep breathing eight weeks before admission. The pain would radiate to the left shoulder. Her condition was diagnosed and treated as malaria by a private physician. Two weeks before admission she noticed a mass in the left upper quadrant just under the ribs which was getting larger. There were no chills or fever; she had a weight loss of ten pounds. The positive points in the past history and the review of systems were: (1) Several bad teeth; (2) high blood pressure for over two years (190 or higher) and she took what might have been digitalis for about one year. She stopped this drug three weeks before admission and one week before admission she developed swelling of her feet and ankles. (3) Her appetite had been poor for two months and there had been bloating after meals. (4) She was operated upon in 1939 for fibroids and had not menstruated since that time. (5) She was given arm and hip "shots" in 1940. (6) There was a positive family history of both fibroids and hypertension.

Physical examination showed a moderate hypertension (176/114) and a temperature of 99.8°F. The head and neck examination were

* From the Department of Surgery, Independent Unit, Charity Hospital of Louisiana at New Orleans. Read before the semi-annual general staff meeting of Charity Hospital, 1945.

essentially normal except for prominent venous pulsations on the right side of the neck. There were bilateral soft nodes in both axillae and an isolated node in the left supraclavicular fossa.

other laboratory findings were normal including the blood serology and pylograms.

I first saw this patient July 4, 1944, and at that time there was a firm smooth mass in the

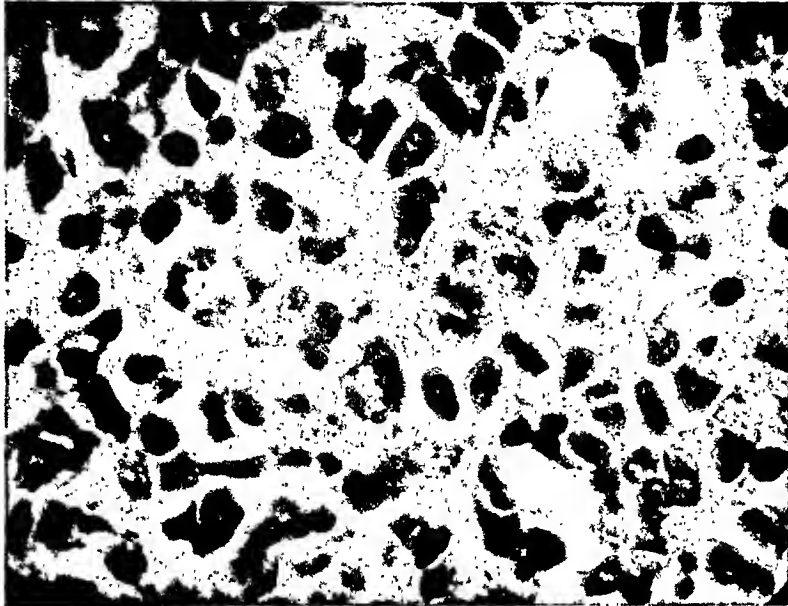


FIG. 1. Microphotograph showing numerous mitotic figures and bizarre anaplastic cells with considerable avascular necrosis due to the rapidity of growth and the parasitic blood supply limitations. $\times 660$.

Examination of the thorax was essentially normal. The abdomen showed a midline healed scar from the umbilicus to the pubis. There was a visible mass in the epigastrium which was firm, movable and not expansile. The mass extended from the left costal margin to the midline and there seemed to be a second mass behind the first one at the costal margin. The liver was just palpable. Extremities showed no abnormalities except tenderness to motion of the right knee joint. She was sent to the medical wards with a diagnosis of abdominal tumor, essential hypertension and arthritis of the right knee. The positive laboratory findings were an anemia of 8.6 Gm. hemoglobin with 2.9 million red cells. The phenolsulfaphthalien test showed a 25 per cent total excretion. Spinal fluid serology was positive and the Lange gold curve was 5553211000. Barium enema showed a downward displacement of the transverse colon by an extrinsic mass. X-ray of the chest showed an elevation of the left leaf of the diaphragm. The gastrointestinal series showed displacement of the stomach and duodenum to the right but no other abnormalities. Icterus index was 8.6. Electrocardiogram showed moderated left ventricular hypertrophy. All

left upper quadrant which moved readily with respiration; with deep inspiration a nodule could be felt on the mass just below the costal margin. I interpreted this as a granuloma of the spleen and asked that the patient be transferred to the surgery service. The medical staff thought that this was most likely a gumma of the spleen in view of the positive spinal fluid findings. The mass continued to enlarge despite full doses of bismuth and iodides. The patient was transferred to the surgery ward August 6, 1944, at this time the mass filled the entire abdomen and had a definite large nodule in its upper portion. There was also two plus edema of both ankles. Impressions by various members of the surgery staff included lymphoma of the spleen, retroperitoneal sarcoma, and retroperitoneal cyst probably of the pancreas. My diagnosis was still an intraperitoneal mass attached to the diaphragm on the basis of the previous findings. A hematology work-up disclosed only a mild anemia and thrombocytopenia with a rapid sedimentation.

She was operated upon August 31, 1944. Under general anesthesia the abdomen was opened through a long left rectus incision. A

large cystic tumor was found filling the entire abdomen and was markedly adherent to the omentum, liver, stomach, pancreas, spleen, and diaphragm, but did not seem to arise from any one of them. The tumor was so tense and firmly fixed in the abdomen that it was thought to be much safer to aspirate its contents before mobilization of the mass was attempted; 5,000 cc. of brownish fluid was removed from the cavity of the mass. Sections of the mass were removed and sent to the pathologist for frozen section studies. The incision into the mass was then closed and mobilization of the tumor was begun. By sharp dissection it was separated from the omentum and the left lobe of the liver. The portion of the stomach adherent to the mass was excised and the stomach closed by the aseptic Parker Kerr method. After separation from the spleen and pancreas the tumor was removed only with great difficulty from the diaphragm by sharp dissection. The abdomen was closed in the usual manner in layers. The frozen section report was leiomyoma.

Her postoperative course was excellent. The sutures were out and the patient was ambulatory on her eighth postoperative day and she was discharged on her tenth postoperative day. After much study with special stains and consultation with many pathologists the final pathological report was "Leiomyosarcoma." The slides of the original fibroids that were removed in 1939 were reviewed and no evidence of malignancy could be found in these sections.

Clinic follow-ups showed no recurrence of symptoms until July 25, 1945, at which time the patient again noticed pain over the left shoulder and a feeling that she had a tumor present whenever she would breathe deeply. There was a palpable hard mass which could be felt with deep inspiration just below the left costal margin. It was somewhat tender. She also had edema of the ankles. All laboratory studies were normal and she was again operated upon August 10, 1945. Through a subcostal incision the entire upper abdomen was explored. A mass about 12 cm. in diameter was found which had infiltrated the entire diaphragm and was adherent to the pericardium. There was a large solitary nodule in the liver and the omentum was thoroughly infiltrated with tumor tissue. It was believed that nothing could be done for this patient and so the abdomen was closed after biopsies of the various masses had been taken. Her postoperative course was uneventful. Pathological

diagnosis was again leiomyosarcoma; the cellular pattern was almost identical with the tumor removed one year before. She was discharged on the eighth postoperative day as the radiologist did not believe that deep therapy was indicated. She was last seen on December 12, 1945, at which time the mass attached to the diaphragm had grown to the size of a football.

COMMENT

The case just presented is a unique complication of a parasitic fibroid. As far as I could determine from the literature there has been no previously reported case of a parasitic fibroid which has reached this size or which showed malignant degeneration, although many very larger cystic uterine fibroids have been reported. The interesting points in the above case presentation was the proven rapid increase in size while the patient was being held under close medical observations. The fact that this patient had had a hysterectomy for uterine fibroids five years previously, shows definitely that there are still a great many elective laparotomies being performed without an adequate abdominal exploration. The sarcomatous nature of the tumor could not be determined by frozen section, but only after very careful study with special stains made on paraffin sections.

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PSEUDOCYST OF THE GREATER OMENTUM

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SEVERAL varieties of primary cystic formations of the mesentery and omentum have been described. They are classified as lymphatic, dermoid, hydatid, and other more uncommon types of endothelial cysts. These are true cysts of the omentum and they are rare. The etiology is unknown with the most satisfactory explanation being that they are congenital and due to some embryological defect or malformation. Primary omental cysts are usually thin-walled and multilocular. They may attain a huge size and usually appear early in life, before the tenth year. They are rarely malignant but when so, usually take the form of a lymphangio-endothelioma. These tumors or cystic masses are doughy, poorly circumscribed, and as a result are not easily palpable early. The treatment is complete surgical excision following which, recurrence is rare. In addition to these recognized and described forms of primary omental cysts, there are also incidents which may lead to the formation of secondary or pseudocysts of the omentum. These may be classified as inflammatory, metastatic growths which undergo cystic degeneration, and foreign body inclusion.

A recent case, admitted to the Surgical Service of this General Hospital, differs from the usual varieties and is rare enough to warrant reporting, though it is a pseudo rather than a true cyst of the omentum.

CASE REPORT

The patient, a twenty-seven year old American soldier, entered our General Hospital October 15, 1944, with a large, painless, abdominal tumor. He was able to move this mass freely about his abdominal cavity. The swelling was noticed about one year before, its first manifestation being a tightness at the waist,

which he thought was due to his "getting fat." Six weeks before admission he became aware that the distention was caused by a movable mass, which had been gradually increasing in size.



FIG. 1. Preoperative appearance of patient with large pseudocyst of omentum.

His past history was essentially negative except for an appendectomy ten years before which had been performed through a two-inch lateral rectus incision. Following appendectomy he remained in the hospital ten days and convalescence was uneventful, except for one episode of sudden, sharp, abdominal pain in the right lower quadrant. This occurred on the thirty-first postoperative day, after the patient had returned to work. He was readmitted to the hospital and remained under observation for twenty-four hours, at the end of which time he was free of pain and was discharged. On admission to our surgical service he had no complaints, other than the vague abdominal distress associated with the tumor.

Physical examination revealed a healthy, 145 pound, 5 feet 6 inch soldier, essentially normal, except for the abdominal swelling. This filled the hypogastrium from the symphysis to the level of the umbilicus and was visible on inspection. (Fig. 1.) It seemed about 6 inches in diameter and was definitely intraperitoneal. It was freely movable, in spite of its large size, from the hypogastrium to the epigastrium, and laterally from the left flank to the right. It was not tender and was fluctuant, though tense.

Routine laboratory tests including blood count, blood sugar level, serum amylase and urinalysis were all normal.

X-ray revealed an essentially normal chest. Gastrointestinal studies, including barium meal, showed no evidence of intrinsic lesions of the

terminal ileum was displaced upward and to the right by a shadow corresponding to the mass. (Fig. 2.)



FIG. 2. X-ray of abdomen following barium enema showing displacement of terminal ileum by omental tumor.



FIG. 3. Omental pseudocyst with base of attachment to omentum.

terminal ileum. There was no evidence of obstruction. The appendix was absent. The postoperative course was uneventful, the patient returned to light duty one month later.

Preoperative diagnosis was omental or mesenteric cyst.

Operation on October 19, 1944, revealed the cystic mass to be attached to the distal portion of the omentum on the right side. There were no adhesions to bowel or peritoneal surfaces. The cystic mass was removed *in toto* with a pedicle of normal omentum. (Fig. 3.) Exploration revealed no adhesions in the vicinity of the ileocecal region and the appendix was absent. The postoperative course was uneventful, the patient returned to light duty one month later.

The pathology report by Lt. Col. B. H. Newman is as follows: Specimen consists of a cyst sac to which is attached normal omentum. The cyst measures 14 cm. in diameter. The surface is smooth with no openings, the wall is from 1 to 4 cm. in thickness. The inner surface is black with a chocolate colored material with some excysted blood. The lining is purple in color to polypoid in appearance. There is also a cottony appearance to the inner surface of the wall of the cyst cavity. The outer surface is smooth and the external surface is lined with a thin layer of simple

Microscopically (Figs. 4, 5 and 6), the wall of the cyst is composed of a loose, fibrous, connective tissue. In places it has undergone

pink staining material are seen. These are surrounded by multinucleated giant cells of the foreign body type. The lining of the cyst is



FIG. 4.

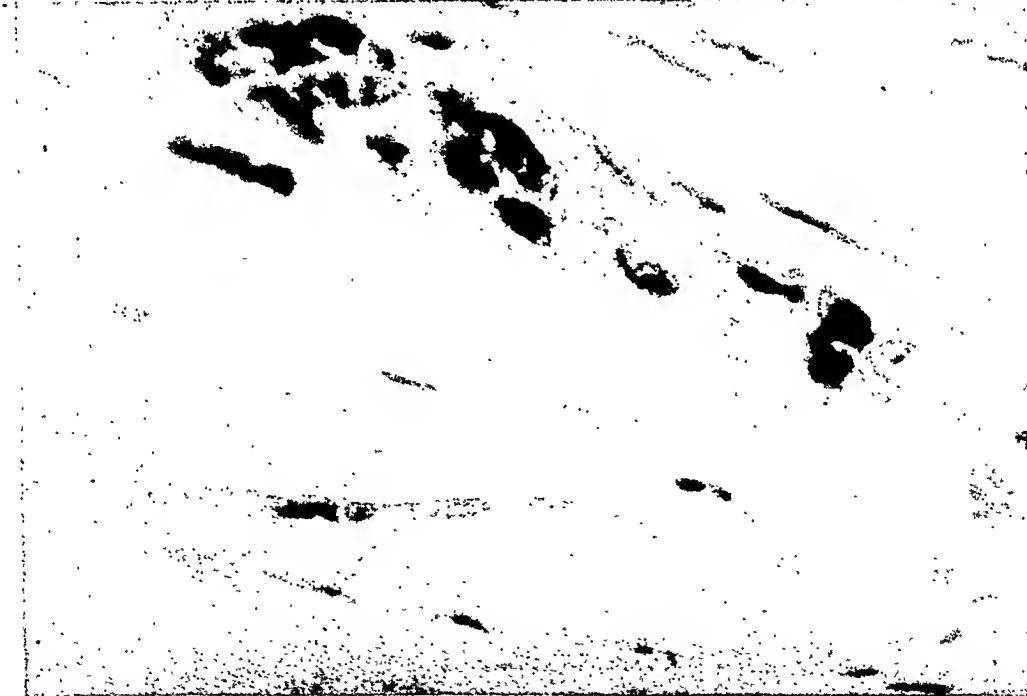


FIG. 5.

FIG. 4. Microphotograph showing the section through the wall of cyst and foreign body composed of eosin-staining thread-like structures surrounded by foreign body giant cells. Note the granulomatous lining. $\times 200$.

FIG. 5. Microphotograph with higher magnification showing the structure of that in Figure 4. $\times 700$.

hyalin degeneration. In its middle third, it is quite vascular and shows channels, some of which contain red blood cells. In some places, in the inner third of the wall, "threads" of

smooth in many places, while in others it shows small papillary projections, comprised of granulation tissue, and diffusely infiltrated by a scanty distribution of round cells. Some larger

histiocytic cells are also seen containing a brown pigment suggesting blood pigment.

Diagnosis: Foreign body granuloma with

abdominal retention of a foreign body is its walling off by a tissue protective mechanism. We believe that such a process



FIG. 6. Microphotograph showing the eosin-staining threads which resemble cotton from surgical sponge. $\times 900$.

cystic degeneration. The foreign body is an ancient abdominal surgical sponge.

COMMENT

Although foreign bodies in the abdomen are not infrequent following surgical operations, the sequelae of such accidents are sometimes of great clinical significance and certainly the patients are not often symptom free. The course of events in this particular case can only be conjectured, as the patient was symptomless for about nine years following the appendectomy, with the exception of the history he had given on the thirty-first postoperative day. The usual course seen following intra-

did take place in this case, but its interest lies in the subsequent changes following the localization. The most likely explanation is that a foreign body granuloma developed and because of a gradually decreasing blood supply regressive changes occurred with the formation of a cyst. This is suggested by the presence of the thread-like foreign bodies seen in the wall of the cyst.

CONCLUSION

An unusual case of an old retained surgical sponge within the peritoneal cavity, and the subsequent formation of a pseudocyst of the omentum, has been presented.



New Instruments

NEW SIMPLIFIED INTESTINAL DECOMPRESSION TUBE*

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WHEN Wangensteen¹ introduced his method of intestinal decompression, it was generally believed among medical men that here, at last, was a method of combatting intestinal distention. That intestinal distention, particularly the postoperative type with its associated gastric dilatation, was reduced was universally agreed upon. However, it was soon found that the tube used in the Wangensteen method did not pass down into the gastrointestinal tract as often as desired, and so often coiled up in the stomach. When this occurred, the stomach was adequately decompressed but the rest of the gastrointestinal tract could be decompressed only when the pyloric sphincter lost its tonus or if reverse peristalsis caused the gastrointestinal contents to pass upward into the stomach.

In an effort to decompress the gastrointestinal tract adequately, Miller and Abbott² introduced a double lumen tube at the end of which a balloon, which could be inflated, was fastened. This balloon acted like a bolus which was then supposed to be carried down the gastrointestinal tract by peristalsis after the bowel had been collapsed by suction. This tube was widely acclaimed by surgeons. We often found this tube to be effective, but were very soon confronted by three objectionable features:

One of the most objectionable features of the Miller-Abbott tube was the ease with which it became plugged by gastrointestinal particulate matter. This necessi-

tated repeated irrigations and very often removal of the tube.

The second objectionable feature was the fact that very often this tube did not pass down into the gastrointestinal tract. When this occurred, the tube coiled up in the stomach and acted no better than the Levin tube. In spite of the various techniques^{3,4,5} proposed to expedite the passage of this tube through the pylorus, the percentage of failures was far from small.

A third objectionable feature was the fact that there were only four small holes above the balloon and several below it. If the tube passed well down into the gastrointestinal tract, the area of bowel around the distal twelve inches of tube would often be adequately decompressed, but the bowel proximal to the end of the tube would often become distended again. This was particularly prone to occur in cases in which there was an exudate in the peritoneal cavity or fluid in the intestinal tract because in these cases the patient would be actually suffering from multiple short-loop obstructions due to the kinking of the bowel creating pockets.

An examination of a cross-section of the Miller-Abbott tube reveals an interesting finding, namely, that the caliber of the lumen used for intestinal decompression is only slightly larger than the caliber of the lumen to blow up the balloon. (Fig. 1.) Since the chief function of the tube is supposed to be intestinal decompression, and the inflation of the balloon only of

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minor importance, it always seemed to us rather incongruous that their luminal diameters should be about the same.

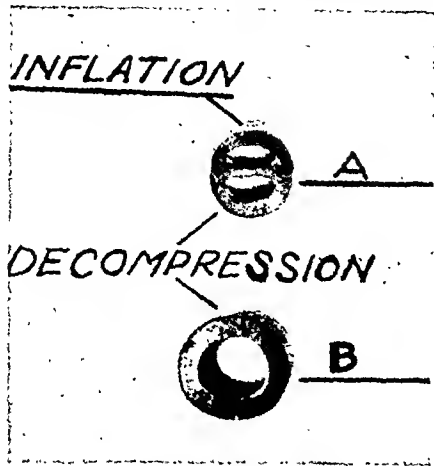


FIG. 1. Miller-Abbott tube (A). Our tube (B). Note that in the Miller-Abbott tube the luminal diameter for suction is about the same as the luminal diameter for inflation of the balloon. Note in contrast the large size of the luminal diameter of our tube used for suction. Magnifications of cross-sections of tube 2 x.

This latter observation was made by Johnston,⁶ who proposed a tube for decompression, attached to which was a second smaller tube used to inflate the balloon. This tube also depended upon inflation of a balloon attached to the distal end of the tube to act as a bolus and thus be carried down the gastrointestinal tract. The diameter of the lumen of the tube used for decompression is one-eighth of an inch and the lumen for the balloon one-sixteenth of an inch.

Both the Miller-Abbott and the Johnston tubes were used with varying measures of success by surgeons everywhere. Most reports were favorable, but everyone stressed the difficulty in getting the balloon to pass through the pylorus.

In 1944, Harris⁷ and also Swertsen⁸ working independently suggested a method by which the balloon could be carried down into the duodenum faster and with a greater degree of success than was formerly possible. They proposed to place a small amount of mercury (5 cc.) into the balloon and by shifting the patient about they were

able to demonstrate that the balloon was readily carried through the pylorus into the duodenum. The balloon was then inflated



FIG. 2. Note that the tube has passed through the entire small intestine and the balloon is now seen in the ascending colon.

and carried down the gastrointestinal tract.

The use of mercury to carry a tube down into the duodenum was not new with Harris or Swertsen, however. It was the fact that they used it in the Miller-Abbott tube for intestinal decompression that was new. Wilkins,⁹ in 1928, in a paper entitled, "Mercury Weighted Stomach Tube," described the use of mercury at the end of a single lumen tube to be used for gastric and duodenal lavage and feeding. Because it was used for that purpose he made his tube forty-six inches long. The compartment for the mercury was four and one-half inches long and three-sixteenths of an inch in diameter. His tube was obviously then not an intestinal decompression tube.

Since it had been demonstrated that mercury placed into the balloon would carry the tube through the pylorus in a much greater percentage of cases than formerly was the case, it appeared to us that the "raison d'être" of the double lumen tube ceased to exist. This would be particularly the case if it could be shown that the mercury in the balloon in itself con-

stituted a bolus which could pass down the gastrointestinal tract either by peristaltic activity, by the effect of gravity, or possi-

sixteenths of an inch and the thickness of the wall of the tube three sixty-fourths of an inch. Four series of holes were made in

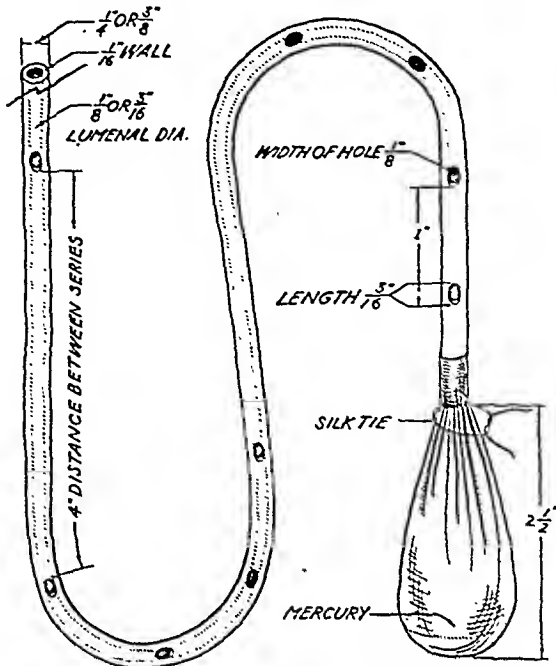


FIG. 3. This is a diagram of the tube giving the dimensions of its various features. Holes are in groups of four.

bly by both methods. (Fig. 2.)

When one considers the problem of intestinal decompression, it resolves itself down to the ability of the surgeon to introduce a tube of soft rubber far down the gastrointestinal tract. To decompress the bowel adequately, this tube must have a lumen sufficiently large that the gases and small particulate matter found in the gastrointestinal tract could be easily suctioned out and yet the tube not become plugged. It would be further desirable to have a sufficient number of holes all along the tube so that the gastrointestinal tract could be decompressed all along the course of the tube, each hole to be sufficiently large that the danger of it becoming plugged would be reduced to a minimum. By the use of such a tube, using the principle of suction one could easily decompress the entire gastrointestinal tract.

With these facts in mind, we took a single lumen tube ten feet long and fastened a rubber condom to the end of it. The lumenal diameter of the tube was three-

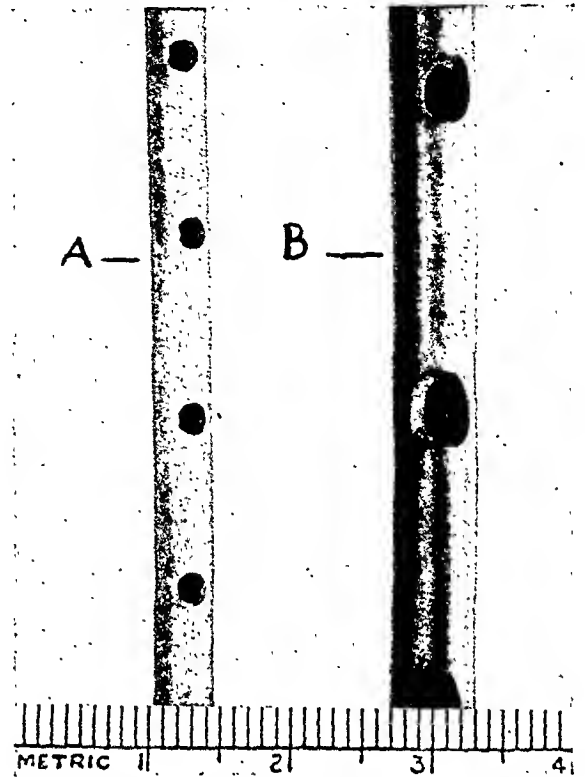


FIG. 4. Note the difference in size and shape of the holes in the Miller-Abbott tube (A), and our tube (B). 2 x.

the tube beginning just above the balloon and running upward for twenty-four inches. The holes were made in groups of four. Each hole being separated from the next to it by one inch. Each series was separated from the next by four inches. (Fig. 3.) In this way, the series of holes were made to run proximally from the end of the tube for a distance of twenty-four inches. The holes were made elliptical in shape, being one-eighth of an inch wide and three-sixteenths of an inch long. The greatest diameter of the hole being along the length of the tube. (Fig. 4.) By making the holes in this fashion we found that plugging was much less likely to occur. After much experimentation, it was found that the optimum length of the balloon must be two and one-half inches. This length permitted the mercury to move about freely and so facilitated the passage of the tube and yet was not so long that it would swing around a loop of tube

in the stomach and so form a knot. This knotting was particularly prone to occur if the condom was made too long or if too



FIG. 5. This is a photograph of the entire tube. It does not show the silk ligature which is tied just below the end of the tube after the mercury has been inserted. This must be done immediately preceding the insertion of the tube into the patient and after all the air has been forced out of the balloon.

much tube was passed into the stomach before the condom had passed through the pylorus. Before being used 5 cc. of mercury was inserted into the condom through the hole just above it, the air present was then forced out, and the neck of the condom was tied off with braided silk just distal to the end of the tube to prevent the escape of the mercury. (Fig. 5.) The single lumen intestinal decompression tube was now ready to be used.

The method of passing the tube was found to be important. Excellent results were obtained in every case in which attention was given to a few simple details. For this reason the following instruction sheet was sent with each tube:

1. Give the patient morphine sulfate gr. $\frac{1}{6}$ and atropine sulfate gr. $\frac{1}{150}$ one-half hour before attempting to pass the tube. This will allay nervousness and also relax the pyloric sphincter.

2. Apply pontocaine 2 per cent to the mucosa of the side of the nose through which the tube is to pass.

3. Lubricate the tube well with mineral oil or some other lubricant.

4. Have the patient lie flat on his back with his neck hyperextended thus throwing the head backward. Then insert the condom into the nose and permit the mercury to run into it while feeding the rest of the condom into the nose. When the entire condom is in the nose, the weight of the mercury will pull the tube down the nasopharynx. Permit the patient to sit up, and have patient drink some water. This will facilitate the rapid passage of the tube downward through the esophagus into the stomach. At this time gently pass the tube downward to a point four inches beyond the last visible hole.

5. With the tube in the stomach, have the patient lie on his right side without a pillow and elevate the foot of his bed ten to twelve inches. Keep in this position for two hours.

6. At the end of two hours, level the bed, and turn the patient upon his back and put up the backrest (Fowler's position). Keep the patient in this position for two hours.

7. At the end of two hours, turn the patient upon his left side while on the backrest. Permit him to lie in this position for two hours.

8. Following this, permit the patient to move about freely and encourage sitting up in bed or permit the feet to dangle. Get a portable check film in twenty-four hours.

Since the holes in the tube extended upward for twenty-four inches from the end of the tube, when the last hole came to lie at the external nares, about ten inches of the tube would be in the stomach. This is so because the stomach is about eleven inches from the teeth and the tube passing through the external nares and nasopharynx would add an additional three inches, thus leaving ten inches of the tube in the stomach at this point. Because the intragastric pressure would quickly cause

the stomach contents to leak over the patient, it was found necessary to insert four to six more inches of the tube at this time. The last hole would now lie in the esophagus and all the patients were very comfortable, while at this time about fourteen inches of tube would be found in the stomach. This would not produce coiling and so the danger of knot formation would be negligible. By this technic, the weight of the mercury and its volatility causes the balloon to be carried toward the funnel-mouth of the stomach, i.e., the pylorus. It readily passes through the pylorus so that on the twenty-four hour x-ray film it will invariably be found well down the gastrointestinal tract. If the nares of the patient is small, a tube of one-eighth luminal diameter is used. In this tube the holes are made smaller. In all other respects the tubes are the same.

The four series of large holes very easily decompress the bowel about the tube using the principle of suction to secure even decompression. The caliber of the holes in the tube and the shape of the holes is sufficiently large to take care adequately of most of the particulate matter found with the liquid in the bowel. Plugging of a tube of this caliber is most infrequent. The four series of holes decompress the bowel far more efficiently than by the use of the Miller-Abbott or Johnston tubes whose luminal diameters and the size or whose holes is much smaller. By shifting the patient about in the positions previously enumerated, the full use is made of the effect of gravity upon the heavy metal (mercury) in the condom. This effect literally "drags" the tube down into the gastrointestinal tract. The condom containing the mercury acts like a bolus and also stimulates peristaltic activity in the collapsed bowel. In some cases of bowel obstruction in which the Miller-Abbott tube is permitted to remain for many days, it has been noted by many surgeons that a secondary dilatation of the stomach is not infrequent. This necessitates the passage of a Levin tube through the other nares in

order to secure gastric decompression. With our type of tube this does not occur, since withdrawing the tube a short distance results in the last holes falling in the stomach and so adequately produce decompression. On the other hand, a fifth series of holes can easily be made in this complication and made far enough above the fourth group as to fall in the stomach even when the balloon is found in the ascending colon. (Fig. 2.)

TABLE I
SUMMARY OF CASES—TWENTY-TWO

Patient	Age	Sex	Pathological Condition	Condition of Patient in Hours
1. H. A.	60	M	Peritonitis (ruptured appendix)	Excellent—24
2. T. M.	50	M	Bowel obstruction (cancer of colon)	Excellent—24
3. F. L.	50	M	Peritonitis (ruptured gastric ulcer)	Excellent—24
4. H. G.	62	F	Bowel obstruction (cancer of uterus)	Excellent—24
5. S. S.	60	F	Peritonitis (ruptured appendix)	Excellent—48
6. A. L.	45	F	Bowel obstruction (post-operative)	Excellent—48
7. M. Y.	63	M	Atonic ileus (retroperitoneal abscess)	Excellent—48
8. B. C.	48	F	Peritonitis (evisceration)	Excellent—48
9. J. B.	55	F	Bowel obstruction	Excellent—24
10. J. R.	65	M	Bowel obstruction (carcinoid of ileum)	Excellent—48
11. M. K.	45	M	Peritonitis (ruptured appendix)	Excellent—48
12. W. P.	50	M	Bowel obstruction	Excellent—48
13. D. C.	73	M	Peritonitis (ruptured appendix)	Excellent—48
14. M. V.	42	F	Bowel obstruction	Excellent—48
15. A. W.	56	F	Atonic ileus (pyelonephritis)	Excellent—48
16. C. C.	46	F	Bowel obstruction	Excellent—48
17. W. S.	25	F	Pancreatitis (atonic ileus)	Excellent—48
18. V. J.	70	M	Bowel obstruction	Excellent—48
19. R. F.	28	M	Peritonitis (ruptured appendix)	Excellent—48
20. I. G.	70	M	Intestinal obstruction	Excellent—48
21. A. K.	46	F	Intestinal obstruction (adhesions)	Excellent—48
22. A. W.	55	F	Atonic ileus (postoperative)	Excellent—24

SUMMARY

Since it has been demonstrated that mercury in a balloon tipped tube will carry the tube down the gastrointestinal tract, there is no longer the need for a double lumen tube. We have presented twenty-two cases of severe intestinal distention which were treated by a single lumen intestinal tube and in which the results were far better than our expecta-

tions. In all cases, the tube was carried far down the ileum or into the colon by the mercury. The caliber of the lumen in the tube used is considerably larger than in the currently used tubes and the number of holes were increased to sixteen. These sixteen holes are spread over an area of twenty-four inches. The size of the holes are also much larger than in any of the currently used tubes and the shape of the holes, we believe, contributes immeasurably to the excellent results obtained as plugging with particulate matter did not occur. Only one word of caution must be uttered at this time; that is, *after the last hole has been inserted into the nose, do not insert more than six inches of tube until the balloon has passed through the pylorus and into the duodenum.* It takes one to two hours for the balloon to pass into the duodenum, then the tube is advanced six inches every two hours. If too much tube is inserted into the stomach before the balloon has passed into the duodenum, coiling of the tube will occur with the resultant danger of knot formation.

CONCLUSION

1. A single lumen tube with a lumen of three-sixteenths of an inch has been found to be the most efficient instrument to induce intestinal decompression.

2. In patients with a small nasal passage, a tube with a narrower lumen can be used. In this type of case, a tube having a luminal diameter of one-eighth inch can be used efficiently. In such a tube, the holes are made smaller but the number of holes remains the same.

3. A single lumen tube of the type we propose is much easier to pass than any other in use. It causes the patient no more discomfort than the smaller caliber tubes.

4. The series of holes along the course of the tube insures that decompression takes place all along the gastrointestinal tract and pocketing is less likely to occur.

5. There is very little danger of plugging of the tube.

6. The balloon invariably comes to lie in the terminal ileum or ascending colon.

I should like to express my appreciation to Dr. C. S. Kennedy without whose support this work could not have been done. All the tubes used were under the direction of Dr. Aulie and Dr. Burnham (surgical residents at Grace Hospital). Dr. H. Jarre of the x-ray department was very kind with most helpful suggestions.

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NOTE: Since this paper was submitted for publication, the number of holes in the tube has been reduced to twelve by reducing the series of holes to three series of four holes each. The tube was then used in twenty additional cases with excellent results.



Film Previews

ANIMATED HEMATOLOGY *

A SERIES of motion pictures titled "Animated Hematology" is planned. The films will deal with such subjects as the macrocytic, iron deficiency, and other anemias, the leukemias, the hemorrhagic diatheses and the rarer diseases of the blood.

The first 1,600 foot film (forty-five minute running time) is now available upon request, for medical and hospital staff meetings and class room teaching. It is primarily concerned with the macrocytic anemias and the mechanism of the hemopoietic principle. It includes pictures of patients, microphotographs of blood and bone marrow smears, diagrams, animated scenes, and outlines the treatment of pernicious anemia, tropical sprue, cirrhosis of the liver and aplastic anemia. The introduction reviews the normal development of blood cells and the results of lack of adequate amounts of hemopoietic principle; Castle's theory is discussed.

The film is in kodachrome; the blood and bone marrow pictures are microphotographs made by direct color photography. It is a silent film but is amply titled and captioned.

The film was produced at the Research Hospital with the collaboration of Professor Robert W. Keeton, head of the department of Medicine of the University of Illinois. Associate Professor Carroll L. Birch wrote the scenario and Assistant Professor Louis R. Limarzi prepared the bone marrow and blood studies. The film was previewed by many authorities in hematology who assisted with valuable suggestions.

The project is sponsored by the American College of Surgeons, is made possible by a grant from the Armour Laboratories and is edited by John H. Glynn, M.D. and Florian E. Schmidt, M.D. of the professional staff.

Sufficient copies will be available for loaning. Requests should be directed to The Armour Laboratories, Medical Motion Picture Department, Chicago 9, Illinois.

* Courtesy of The Armour Laboratories, Chicago, Ill.

THE DIAGNOSES AND TREATMENT OF LEUKORRHEA—A CLINICAL PRESENTATION*

Dr. William Bickers, Associate Professor of Obstetrics and Gynecology, Medical College of Virginia, Richmond, Virginia, was the Director of this production. The film is intended to be used as a teaching aid in medical schools, and for demonstration purposes to general practitioners.

This film reviews the general subject of leukorrhea, differential diagnoses as to various causes and treatment of specific and non-specific leukorrhea. It is a 16 mm. sound film in color.

The company expects to make this film available in the Fall, 1946, and it can be obtained by a request in writing to Ciba Pharmaceutical Products, Inc., Summit, New Jersey.

THE TECHNIC OF SPINAL ANESTHESIA WITH NUPERCALINE*

The Director of this film's production was Dr. Kenneth M. Heard, Toronto, Canada. It is intended to demonstrate the technic of spinal anesthesia employing a modification of the Howard-Jones technic. It demonstrates the use of spinal anesthesia alone and in combination with intravenous barbiturates and cyclopropane. It is a 16 mm. sound film in color.

The film is available at this time and can be secured upon request in writing to Ciba Pharmaceutical Products, Inc., Summit, New Jersey.

* Courtesy of Ciba Pharmaceutical Products, Inc., Summit, N. J.

The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-fifth Year of Continuous Publication

VOL. LXXII

AUGUST, 1946

NUMBER TWO

Editorial

A LETTER—EARLY POSTOPERATIVE AMBULATION

THE editorial by Dr. Roy D. McClure in the October, 1945, number of the *American Journal of Surgery* is right down my alley. His critical judgment of Hilton's conception ("physiological rest"), his correct interpretation of "The Fixed Period" (Osler's unfortunately misquoted and misunderstood lecture), and his penetrating analysis of Leithauser's more recent experiences are timely and suggestive.

More than twenty-five years ago I began, in a more or less conservative fashion, to allow my patients to move about freely in bed after operation, to encourage them to use their limbs and to sit up and get out of bed earlier than was then the custom. We observed no immediate ill effects or after results. When I started practice, it was the rule to keep all patients who had been operated upon for hernia in bed for four weeks. We reduced the time to three, then to two weeks and finally to ten days. At first I was skeptical and unwilling to go too far; for I had noticed that here and elsewhere some surgeons were using the early-rising and early-home idea merely to draw attention to themselves.

It was not until 1922, when a surgical service was established at the North Carolina State Hospital for the Insane, that I became convinced of the relative harmlessness of permitting patients, even following capital operations, to get up and around in the early postoperative hours. More

through necessity than from choice these mental patients were permitted to do as they pleased. We had forbidden bodily restraint of any kind; in a few cases canvas sleeves, covering the hands, were employed to prevent tearing off of dressings, and defilement of incisions.

It was not very long before things began to happen. Once at midnight a nurse called on the telephone to report that Mrs. X, who had had an interposition operation for uterine prolapse performed that afternoon, had got out of bed, been to the bathroom and was then walking up and down the corridor. My answer was, "let her alone." What happened? In a little while she went back to bed of her own accord; and during the two weeks' "convalescence" she was up when she liked and in bed as she willed. The final result, both symptomatic and technical, was the best we had ever attained in that type of operation. There was no instant disturbance of the sutures and healing proceeded satisfactorily. The patient remained in the institution for a long period and was examined as late as five years after operation, definitely cured of her prolapse. Thirty-odd other patients were subjected to the same procedure, submitted to the same postoperative régime and came through with no untoward effects.

It might be presumed—and naturally so—that the interposition operation would

represent the severest test and the most uninviting procedure for early postoperative mobilization. Our hind-sight conception was that the absence of complications might be owing to the fact that in the upright position the abdominal pressure fell upon the posterior aspect of the uterus, keeping it forward, thus obtaining the desired objective; whereas, with the patient flat on her back, the pressure would tend to bear upon the anterior surface of the uterus. To be considered also is the freedom from catheterization in patients who were allowed bathroom privileges.

In all other operative patients at the State Hospital, extending over a period of seventeen years, including operations on the gallbladder, stomach, intestines, chest, perineum, for hernia and hemorrhoids, etc., the same lack of restraint and voluntary behavior was granted. In no instance was there any imperfect result which could be attributed to early ambulation.

In respect to early mobilization there is a marked difference in behavior between insane patients in an institution and apparently sane patients in a general hospital. It would be difficult, indeed, to persuade or successfully to order all our patients to get out of bed on the day of operation or even during the first few days. To them it would be painful, frightening, out of the question. In many instances it is impossible to induce them to move about in bed, much less to stand on their feet or sit in a wheel chair during the first week after operation.

With the insane, however, it is compara-

tively easy; and in many cases needful, to satisfy their restless desires to roam about, to follow their inclination, unheeding, as they are, of pain and fear. The mentally diseased person is already conditioned, has had his recoil from society and is living in a world of his own; the normal patient in our ordinary cosmos still has his psychic fears and reacts accordingly. It would be surprising to the uninitiated to observe how readily the psychopathic institutional patient approaches a surgical operation and how seldom any violent reaction occurs.

My years of experience in the surgical service at the State Hospital encouraged me to proceed further with early mobilization and ambulation. Up to my retirement in 1938 I continued to urge all my patients in general hospitals to adopt it whenever I possibly could. Many of them positively would not even attempt to get out of bed and stand upright on the day of operation. I wish I could have been half so successful in the trick as Leithauser seems to have been.

Certainly we have all heretofore routinely kept most of our patients in bed too long. Comes now the opportunity to test time against performance, to gain experience at the expense of expediency. Without doubt the proposal, in Dr. McClure's words, "merits further consideration and trial," guided, I may add, by selective judgment. We might after all be able to prevent some of the calamities previously considered providential.

HUBERT A. ROYSTER, M.D.



Original Articles

CONSERVATIVE GYNECOLOGY

ARTHUR E. HERTZLER, M.D.

HALSTEAD, KANSAS

CONSERVATIVE gynecology seeks to conserve the woman. Really it might be better to call it preservative gynecology. Her essential apparatus centers in the endocrine system. True enough the ovaries are not the only stars in the endocrine constellation, but they are the only ones accessible to amateur operators.

When I was in Berlin I attended Professor Olshausen's clinic. He was the first man in any country to have removed a hundred pairs of ovaries. But in my day he was the most conservative man I have ever known. He knew what he was talking about. He was human and a man of courage and saw the sufferings castrated women undergo. He wrote a monograph on the subject which I still possess. "Never, no never, remove all of both ovaries" he vehemently proclaimed. I can still hear the agony of his tones as he proclaimed: "I have seen enough."

The daily experience in my clinic is really shocking. Young women with their pelves "cleaned out," even unmarried girls under twenty. As many as five such patients come to the clinic in a single day.

Leaving Berlin, I later had the chance in my position as hospital pathologist to section hundreds of ovaries removed by regular surgeons for what they called dysmenorrhea due to cystic disease. This was known as the Batty operation, not because it was that but because it was the name of the surgeon who first advocated this type of operation for anything the patient complained of. There were small cysts all right but they were like the ovaries

I took with me to Berlin which Gebhard pronounced normal follicles.

The primary trouble is that few surgeons are pathologists. An exact knowledge of pathology is the primary requirement for any conservative operation. It is definitely a knowledge of pathology of the operating room. When the material removed comes to the pathologist, it is too late. Because of an ignorance of normal structure, developing follicles are regarded as pathologic. Few realize how small a piece of ovarian tissue is required to preserve the menstrual function. Olshausen's statement that a piece of ovarian tissue the size of a grain of corn will keep up the menstrual function still holds good. The surgeon must know, tissue in hand, where this necessary bit of ovarian tissue is located in order to preserve it.

Few teachers of pelvic surgery, it seems, realize that to maintain the integrity of the ovary, enough of the endometrium must be preserved to insure the continuation of menstruation. These teachers turn loose a hundred graduates each year who do not know the end results of destroying the menstrual function. If these teachers knew the end result as the general practitioners, and the husbands, see them, the students at least might be different. If endometrial tissue must be preserved in order to insure the integrity of the ovaries, it naturally followed that the entire uterus must not be removed even for tumors of any size during the period of menstrual activity of the patient.

All that is needed to do a conservative operation is to know that it can be done

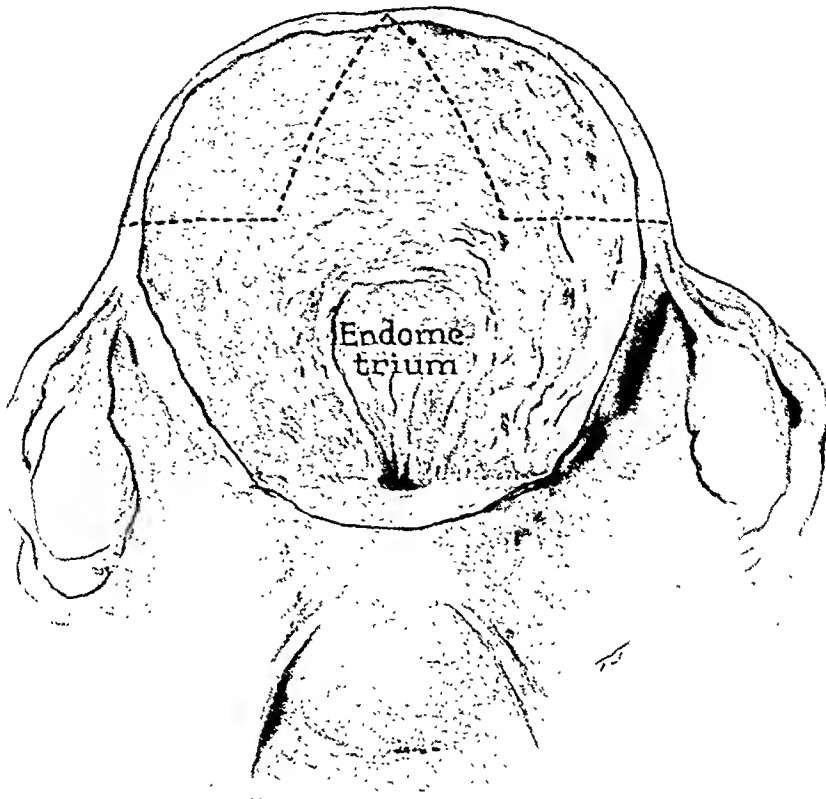


FIG. 1. The tumor has been removed and the redundant uterine wall trimmed off leaving an area of mucosa.

and the will to do it, backed of course by a knowledge of pathology.

I was possessed of this knowledge when my first patient presented a concrete problem. As I stood beside the operating table holding in my hands a uniform myoma the size of a fetal head, and hemorrhagic, the shades of Olshausen whispered in my ear that inasmuch as I did not wish to destroy this patient's nervous equilibrium I must preserve the ovaries and a part of the endometrium. The problem was just as simple as that, because I knew my gross pathology. I exposed the endometrium and circumscribed an area of endometrium about 2 cm. in diameter. (Fig. 1.) I then removed the tumor and trimmed off the enclosing uterine wall until I could fold it over the preserved endometrium. The flaps were sutured in place. (Fig. 2.) Today, I would cover the suture lines with the round ligaments. (Fig. 6.) The patient was an

exceptionally brilliant young woman who later gained national eminence in women's work. Had I done a hysterectomy I would have preserved only a neurotic woman, lost to all usefulness.

My present technic is a build-up requiring more than forty years to accomplish. I shall refer briefly to some of my early steps. It will be well to present a schematic figure in order to make the various steps easier to comprehend. (Fig. 3.) A shows the lesion which may be a tumor or a hyperplastic endometrium. The pathologic lesion, B, shows the reconstructed fundus; C, the completed operation with the round ligament covering the defect.

The first step in conservative operation is to know exactly with what one has to deal. When I do not know what caused a bleeding, I look to see. That is not exactly right; I do not look, but feel. If one's finger cannot tell hyperplasia of the

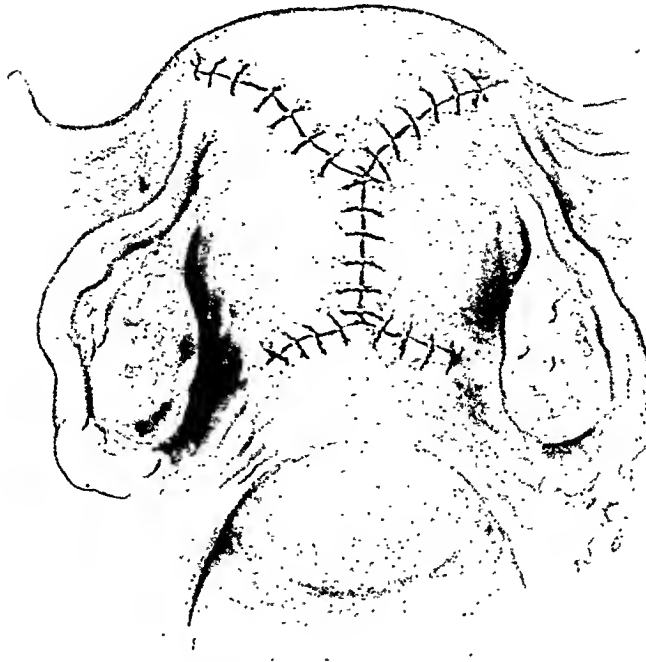


FIG. 2. The wall of the uterus has been folded in to cover the mucosa.

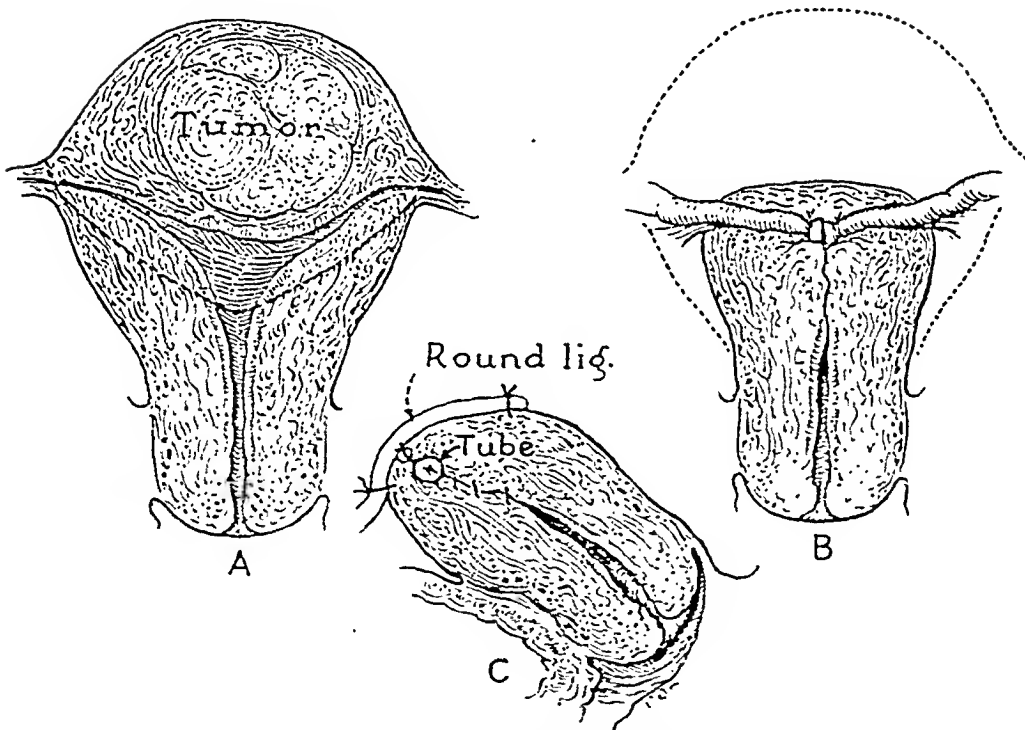


FIG. 3. Diagrammatic presentation showing the underlying principles of all conservative operations: A, the pathologic lesion has been removed; B, the uterine wall is closed after the ends of the tubes and broad ligaments have been pulled in; C, the round ligaments cover the suture line of the incision.

endometrium from carcinoma, he needs more training in gross pathology. I heard Olshausen say nearly fifty years ago that it could be done, and I believed it could be learned.

With Figure 3 in mind the details of

technic become clear. Figure 4A shows the pathologic lesion in process of removal. One explores the entire endometrium, including the cervical canal. The extent of the pathologic lesions being determined and removed, the closure of the wound is

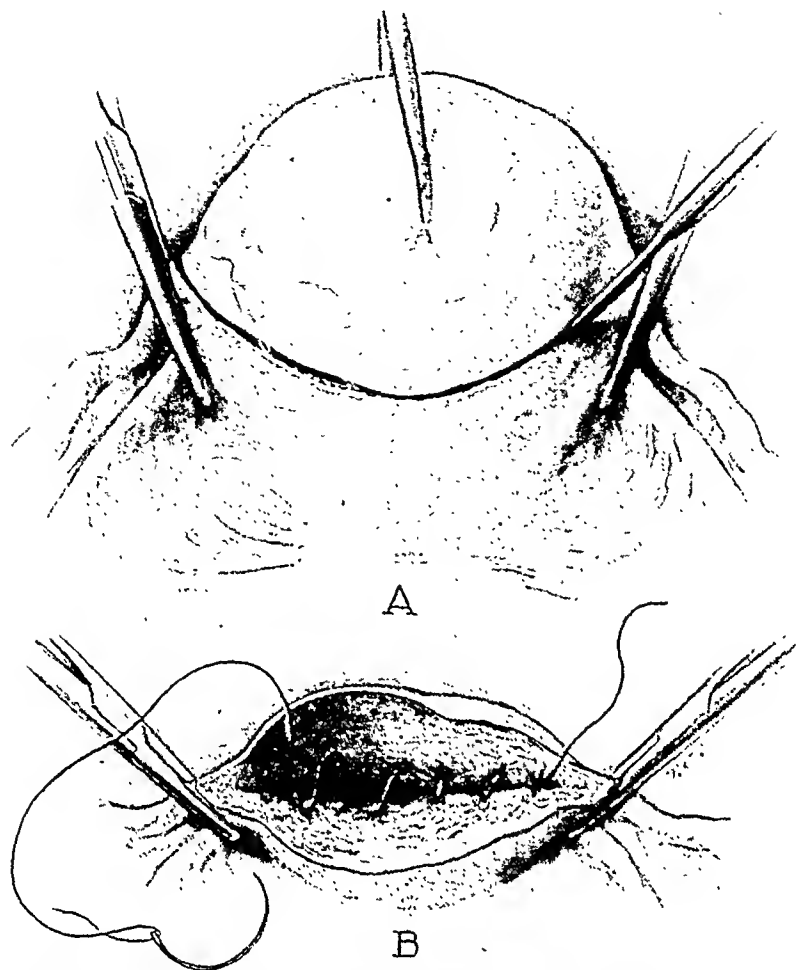


FIG. 4. The technic is shown more in detail: A, the pathologic lesion is removed; B, the first line of sutures beginning the coaptation of the cut uterine wall is placed just above the preserved endometrium.

in order. (Fig. 4B.) The first line of sutures is placed just above the preserved endometrium. Figure 5C shows the remaining uterine wall coaptated in order to control bleeding. The ends of the tubes and round ligaments are drawn together. (Fig. 5D.) In Figure 5E the uterine wall is coaptated.

The most important step in the operation cannot be shown in a picture. The uterine flaps must fall together. If a pull on the suture is needed to bring the flaps together, they will tear out. This may be obviated by covering the suture line in the wall of the uterus with round ligament and the adjacent peritoneum. (Fig. 6.) By judicious application of these sutures the uterus is held in its normal position

even though it was retroflexed before the operation.

As a bit of facetiousness, I have been in the habit of telling my students that the first ten thousand thyroidectomies are the most difficult. A more cheerful remark can be offered here. After the first thousand operations, all the points mentioned above become automatic.

A number of pitfalls must be pointed out. Some operators not satisfied with a hysterectomy, do a panhysterectomy. The handle of the pan is of course the cervix and the skillet is the rest of the tumor. The argument for this operation is that the cervix if allowed to remain may develop cancer. That is a delusion. I

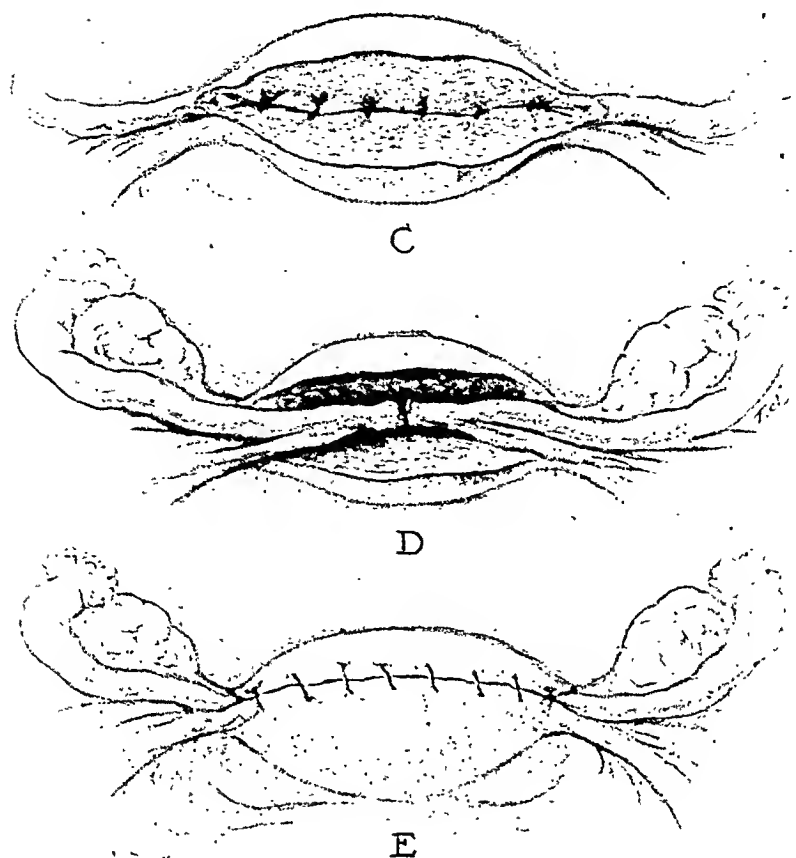


FIG. 5. C, coaptation completed. As many lines are placed as needed to control the hemorrhage. D, the tubes and round ligaments are drawn together. E, the edges of the uterine wall cover the ends of the tubes and round ligaments.

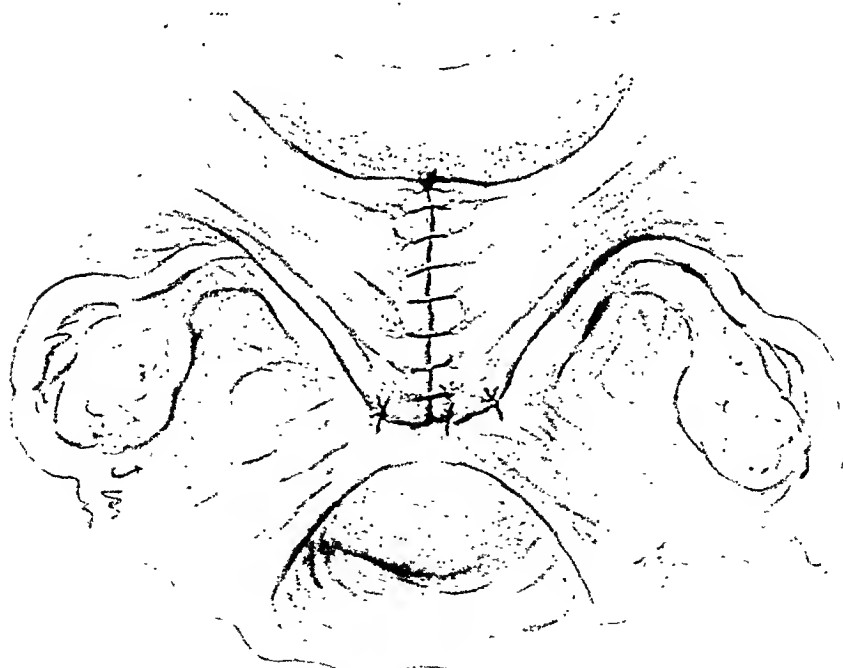


FIG. 6. The suture line in the uterus is covered by the round and broad ligaments. This secures the suture line and also prevents the formation of endometrial fistula.

have seen but one cancer of the cervix after a hysterectomy in all my experience. I saw this patient three months after the supracervical hysterectomy for myomas. She had a well developed cancer of the cervix. The previous operator was one who cut first and looked afterward, only in this case he did not look before or after.

The point is that the cervical canal should be explored before the lesion of the uterus is attacked. If this is not done before the abdominal incision is made, one can when the lesion is exposed explore the cervical canal with a curet.

The panhysterectomy advocates admit that the vagina is shortened. But this does not bother the operator. But when Papa asks the family doctor, it is different.

Just to indulge in a bit of air conditioning I shall indulge in a parting kick. It is generally recognized that it is the unloaded gun that causes the fatal shooting. Radium is the unloaded gun to the owner of the radium. Too often now when there is bleeding from the uterus a piece of radium is inserted and the operator waits to see

what happens. Too often plenty happens. Its chief advantage is that it requires not the remotest knowledge about pathology, beyond the recognition of escaping blood and this can be determined by hear-say evidence. Radium most assuredly has its place but only for the cure of diseases in which the nature of the lesion is known and can be written on the chart where it can be shown the attorney for the plaintiff. The use of radium involves something more than just the forearm muscles to push it in. The use of radium, and x-rays as well requires as wide knowledge and experience as does a pelvic operation.

CONCLUSIONS

The purpose of this paper is to call attention again to the havoc wrought on the women by destroying their menstrual function, and to indicate in a brief way the technic to be followed in doing the conservative operation.

The old adage holds here: Where there is a will, there is a way. The will comes when the problem is understood.



BOILED CARTILAGE IMPLANTS*

CHARLES FIRESTONE, M.D.

SEATTLE, WASHINGTON

THE history of tissue transplantation in general, and cartilage implantation in particular is not deemed contributory to this discussion. It is sufficient to state that cartilage has emerged as the optimum material for use as supportive tissue in improving congenitally bad cosmetic facial contour, and in rebuilding facial and cranial contour rendered poor by external trauma and/or by suppurative processes.

For a long period following the emergence of cartilage as the corpus electum for the purposes above stated, the source of the cartilage was almost wholly confined to the patient who was to be the recipient of the implant. This procedure still has its adherents among some plastic as well as cosmetic surgeons. Maliniac¹ as recently as August, 1945, advocates transposition of the upper lateral nasal cartilages to fill defects in the middle third of the dorsum nasi. It is interesting and somewhat ironical that in the very issue of the "Archives" that contains Maliniac's manuscript, Griesman² points out that these very cartilages transposed by Maliniac are necessary for the nasal pyramid to resist narrowing of the nasal cavity.

This procedure came to be known as the iso implant, and yielded suitable cartilage. It was timely in each instance, since the cartilage was obtained at the operation at which it was needed, and its structure and consistency was adequate, since most patients who sought cosmetic corrections were subjects of ages possessing cartilage that was of sufficient hyalin content, had adequate tensile strength and was generally shapeable to meet the exigency of the particular case. Preserva-

tion problems just did not exist, since each patient ipso facto was an excellent material source for his own needs.

Disadvantages, however, were legion. Each cosmetic surgical operation requiring cartilage implantation of necessity had to be fathered by a prior operative procedure, which was definitely a non-cosmetic one; i.e., the surgery incidental to obtaining the cartilage. Since the cartilage was generally obtained from the thoracic cage, it produced debility and morbidity out of all proportion to the morbidity produced by the actual cosmetic correction. In one of the author's cases, the patient developed a circumscribed pulmonary congestion, with pleuritic pain and fever, and was diagnosed by the internist as suffering from induced pneumonia. In some instances this twin procedure also constituted a deterrent for the individual seeking cosmetic correction.

Time, however, had wrought changes that impelled cosmetic surgeons to seek and find other sources than the patient himself. The morbidity of the parent operation and its deterring influences on the patient, were not alone the causes that impelled the cosmetic surgeon to seek other sources. The dynamics of time and the mutations of modes also acted as compelling stimulants for the search. Patients no longer parenthetically in the younger generation, appeared on the scene desiring cosmetic corrections. Adults whose ages had wrought physiological changes in their own cartilage, changes which had rendered it inadequate for implants, were impelled by economic strivings, and some by their egos, to seek belated corrections of their aging facial contours. Thus the

* Presented at the annual meeting of the American Otorhinologic Society for the Advancement of Plastic and Reconstructive Surgery at the New York Academy of Medicine, November 15, 1945.

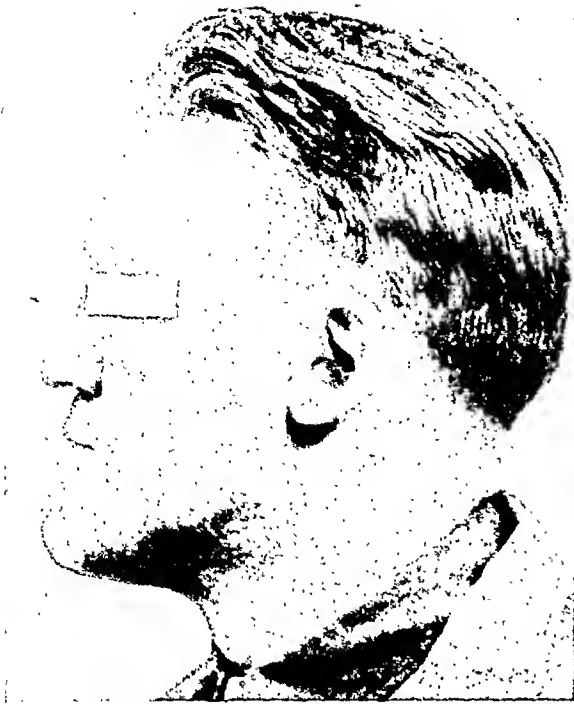


FIG. 1. Patient with depression of lower third of nasal pyramid, resulting from a blow sustained in a boxing match. Surgical attempt at cosmetic correction three years previously ended in failure. Correction was effected by implantation of boiled homocartilage from two separate ethnic sources. A strut of cartilage from a melanderm subject was employed for the elevation of the nasal tip. A strip of cartilage from a leucoderm subject was implanted over the dorsum. Both implantations were accomplished at the same operative session.



FIG. 2. Appearance of patient three months subsequent to implantations. No difference in intensity of reactions was discernible at the sites of implantation.

homo-implant came into being and today is generally employed by cosmetic surgeons as the cartilage implant of choice.

SIGNIFICANCE OF SOURCES

With the emergence and the adoption of the use of the homo-cartilage implant, there arose the problem of preservation of the cartilage after it was obtained from its suitable source. Suitable source is not here referred to categorically, since not all are agreed on the suitability of the source. Straith and Slaughter³ advocate the use of middle-aged cartilage, for the reason, they state, that such cartilage does not contain too much fibrous tissue, nor has it undergone too much calcification. Many others, including this author, have found middle-aged cartilage too brittle,

and have been inclined to employ the cartilage from subjects thirty-five to forty years of age, after having planed away the outer or fibrous portion. Suitability is thus somewhat of a moot question.

Straith and Slaughter³ also adduce the collective observations of Born,⁴ Rand and Browne⁵ and Ullman,⁶ together with others, Quoting them, "That, in general, transplantability increases with the ontogenetic and phylogenetic primitiveness of the organisms which serve as hosts and donors, . . . and emerge with the following dictum of their own: . . . The further removed the relationship of individuals, the fewer chemical characteristics the individuals have in common, and in attempting transplantation of tissues between individuals, the presence of these unlike chemical characteristics in donor and host is the basis for reaction."

This author has repeatedly utilized cartilage from a Japanese subject, and from a colored subject, for transplantation into caucasian hosts. In two cases (to be

illustrated) he has implanted cartilage from twin sources as far apart as negro and caucasion, and Japanese and caucasion, into the same host, without obtaining any reaction differential. In one case (to be illustrated) heterogenous, (bovine) cartilage was implanted. This implant did produce an increased reaction, which can be utilized in some instances as ends in themselves. Caucasion cartilage was in one case implanted into a Chinese recipient without any noticeable reaction differential.

It is not amiss to note at this juncture that the author's observations, resultants of experience as they are, while pointing divergences in suitabilities of cartilage sources, impart data of perhaps greater significance to the related science of anthropology. It rests, of course, with the anthropologist to evaluate and correlate them into his particular scientific scheme. However, to a profession ministering to the ailing of a badly disordered world these observations bear with them corollaries of major significance. If transplantability of cartilage is a coefficient of likeness of chemical characteristics, (as argued by Straith and Slaughter and the authors they quote, and by others not quoted,) these observations would definitely indicate that ethnic differences as far as chemical characteristics are concerned, are purely mythical, or so infinitesimal as to be undiscernible, and would deal a mortal blow to the racists generally. These observations indicate that God has created mankind in one general chemical image, even if the biblical quotation of "God created man in His own image"⁷ is not accepted by all. They also accentuate the principle of the venerated French philosopher Blaise Pascal (1623-62) as quoted by Huxley,⁸ to the effect that "The whole succession of men through the ages should be considered as one man, ever living and always learning."

PRESERVATION AND STERILIZATION

O'Connor⁹ adopted the use of 1 part of 1:1000 solution of merthiolate mixed with



FIG. 3. Frontolateral view of patient with mal-developed nasal pyramid.

4 parts of normal sterile saline as a preservative for the cartilage, storing it in this solution under refrigeration, culturing and changing the solution at relatively frequent intervals. Straith and Slaughter³ practice the same procedure. The term employed by each of these authors to the preservative solution is "merthiosaline." O'Connor's dictum of the above preservation procedure has become relatively ex-cathedra, as it has had wide acceptance and usage, at least in this country.

Lamont¹⁰ states that cartilage is taken from patients "in exitus," fixed, and preserved in merthiosaline. The phrase "in exitus" employed by Lamont, besides strongly implying viability as desirable, produces a bewildering reaction even in the professional individual who may find himself in exitu. By way of comment, this author would insist, in his own particular case, that his own cartilage be removed *in statu post exitum*.

Straith and Slaughter³ state: "Homo-grafts, whether used as fresh or as preserved material, have about equal advantages as far as the question of immediate result at the site of implantation in the new host is concerned. Live homo-grafts



FIG. 4. Lateral view of same patient as in Figure 3 showing her average attitude of expression.



FIG. 5. Lateral view of same patient three months following reconstruction of dorsum by implantation of boiled cartilage from xanthoderm subject. The nasal tip remains relatively low for optimum cosmetic result.

are transplanted with the knowledge that they will probably become at least partially necrotic and eventually be invaded by connective tissue, even though it may be more or less viable." These authors continue; "The preserved cartilage . . . will not be viable but will act as a tolerated foreign body, and, because there is no active metabolism, it will not initiate such active tissue response on the part of the host." It is difficult to reconcile the authors' statements with their advocacy of the use of mild merthiosaline as preservative.

The procedure of the three authors successively referred to above is generally representative. The statements and techniques of these authors emanate an aura of adherence to viability. In the application of these techniques, these authors definitely practice in proximity-to-viability fashion. Thus, O'Connor tends to confirm the aura of viability by stating that in particular cases he injects merthiosaline into the graft bed. Inferentially this mild merthiosaline inhibits and destroys pathogenic organisms of live organic composition, without having the same effect on organic

tissue in the graft bed. Straith and Slaughter state: "Too great a concentration of mercurial salts in the cartilage may result in a purely chemical irritation in the new host. An effort to maintain as nearly as possible a physiologic solution and yet maintain sterility is the method of choice." In brief, the last sentence admonishes the reader to adhere as close to viability as feasible. Yet these authors conclude that preserved cartilage is more suitable and, as implants, will be better tolerated by the recipient. Lamont remains even closer to viability by his removal of the cartilage from subjects "in exitus" as he states.

In the opinion of this author these procedures are not only non sequitur but assume an aspect of sheer sophistry when considered vis-a-vis the acceptance by all of these authors, that the foreign body implant is the optimum implant. If cosmetic surgery is a science as well as an art, the scientist in the cosmetic surgeon should, and, indeed must, act on his intelligence of scientific data, and on the conclusions he has reached. If sterile

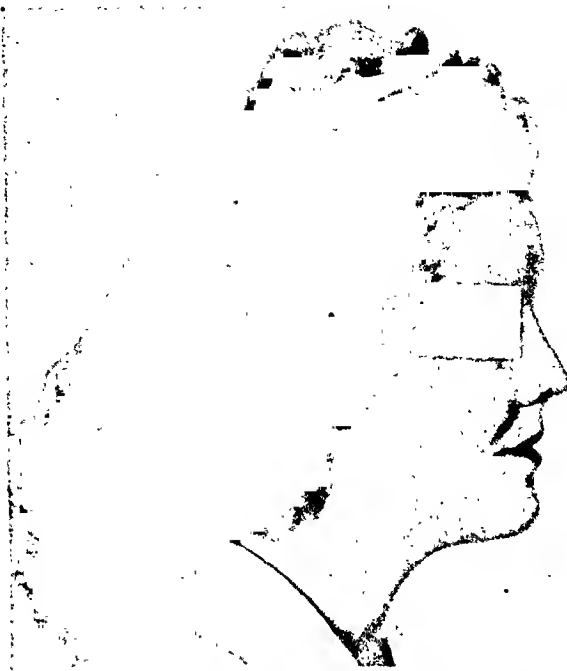


FIG. 6. Lateral view of patient two months following second implantation. A boiled cartilage strut from a leucoderm subject was implanted via the sublabial route for the purpose of raising the nasal tip after loosening the columellar base. No difference in tissue reaction was discernible. The slight elevation of the nasal tip afforded that subtle entity which yielded the desired cosmetic result.



FIG. 7. Front view of same patient two months following second implantation of boiled homocartilage.

preserved cartilage is deemed optimum for implantation purposes, do not the methods of the above authors stand out in bold relief as contradictory? What better means of obtaining this desired end is known to the medical profession than accepted adequate chemical preservatives, and/or the destruction of pathogenic organisms by the all accepted method of boiling?

AUTHOR'S METHOD OF PRESERVATION AND STERILIZATION

This author has adopted procedures giving practical effect to this reasoning. Cartilage obtained in the usual manner has been employed. Two of the sources were from subjects who had been embalmed and prepared for burial three days previous; one a xanthodermic (Japanese) subject, the second a melanodermic (negro) subject. The cartilage from a third leucodermic source was dispatched to the author's office in a 10 per cent formalin solution.

In each instance the cartilage upon reaching the author's office was vigorously boiled for twenty minutes. It was found that the enucleation from the perichondrium was greatly facilitated. The cartilage was then placed in a 50 per cent solution of alcohol and kept therein at room temperature until the need for it arose. In one of the cases (to be illustrated) heterocartilage was employed.

When need for the implants arose, the vessels containing the cartilage were taken to the hospital. Pieces of desirable size were removed from the alcohol, washed in tap water, wrapped in gauze, and boiled vigorously for twenty minutes in the sterilizer, together with the instruments. The boiling removed all trace of the preservative. They were then brought to the operating room by the attendant nurse, shaped to fill the particular contour deformity, perforated and implanted in the routine manner. As previously stated, cartilage from negro and Japanese subjects were implanted, together with cartilage from caucasians, into the same caucasian recipients in combined or in separate operative sessions. Results have been uniformly favorable. Some cartilage will



FIG. 8. Patient with extensive depression of forehead following surgical removal of portions of the anterior tables of the frontal bones, subsequent to injury sustained in a motorcycle accident.



FIG. 9. Appearance of patient following implantation of iso-cartilage. Implantation was effected through entrance at the site of the old longitudinal scar on forehead. Patient developed pulmonary congestion at site of removal of cartilage, with uneventful recovery.

exhibit a slight tendency to curling following its removal from the sterilizer after boiling. This is a fortunate occurrence, since it apprises the surgeon the direction of possible post operative curling, and thus yields a guide to the placing of the implant.

HETEROCARTILAGE IMPLANTS

Heterocartilage implants (bovine) hold promise of major importance to cosmetic surgeons for use in locations where a panniculus is desired either as an end in itself, or as an end in combination with the substantive cartilage. Where soft cushiony parts are maldeveloped or become depressed following destruction of soft subcutaneous tissue by trauma or other pathological processes and require elevation for cosmetic improvement, heterocartilage may be implanted for its reaction in producing the fibrotic invasion integral to its encapsulation, and may be removed when the panniculus composing the capsule has attained the desired elevation.

Further experimentation can alone determine the quantitative and temporal aspects necessary for accomplishing the desired panniculus

ADVANTAGES

An appraisal of the procedures advocated in this paper reveals definite advantages over the procedures generally in vogue!

1. They give practical expression to the conclusion agreed upon by all cosmetic surgeons that foreign body cartilaginous implants are preferable to viable cartilaginous implants.
2. The methods of preservation and sterilization ascertain the annihilation of viability by rendering the cartilage implant an inert foreign body.
3. They bring into use additional sources of suitable cartilage for implantation, eliminating the need for limitation of cartilage sources to subjects of co-ethnic



FIG. 10. Patient suffered injury in early childhood resulting in depression of the bony interorbital region, the superior portion of the nasal bones, and the superior inner portions of the orbital margins. Subintegumentary fascia was destroyed resulting in adhesion of the integument to the periosteum.



FIG. 11. This illustrates patient's reaction to heterocartilage (bovine) implantation and is not submitted for its cosmetic accomplishment. The implant was well tolerated and produced an overabundance of fibrotic reaction. A single implant was necessary. Human cartilage dimensions proved inadequate for supplying an implant as needed.

descent. Otherwise stated, they permit cartilage implantation from xanthoderms to leucoderms, from melanoderms to leucoderms, from leucoderms to xanthoderms, singly or in combination.

4. These methods of preservation eliminate the need for refrigeration and frequent changing and culturing of the preserving fluid.

5. The boiling extracts any trace of water-soluble proteins that may be present in the scant fibrils or in the lymph channels of the cartilage, and ensures sterilization of the implant.

6. The boiling removes all traces of the preservative, thus removing the possibility of chemical irritation to the bed receiving the implant.

7. These procedures introduce into usage the heterocartilage implant as a means for its reaction-begetting value of producing a panniculus where subcutaneous soft tissue needs filling. They render feasible the use of heterocartilage implants as ends in themselves, or in combination with their

use as a means for production of the panniculus.

CONCLUSIONS

1. Implants of boiled human cartilage produce minimal reaction in the host.

2. Ethnic differences within the human genera do not affect transplantability of cartilage. The cartilage from subjects of a given ethnic group is transplantable to subjects of another ethnic group without producing discernible reaction differentials.

3. Cartilage from two subjects each of which belongs to a separate ethnic group is transplantable in combination to subjects who belong to neither of the ethnic groups of the donors, without producing discernible reaction.

4. Heterocartilage (bovine) is transplantable to the human, and holds promise of becoming the implant of choice because of its coefficient of increased reaction in locations where subcutaneous soft tissues require elevation. It may be employed as a means for attaining the elevation of the

soft tissue, or as an end, itself to be retained, or in combination.

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THE main indications for bone grafting in the mandibular region are (1) non-union resulting from bone loss, initial or due to sequestration, and (2) mal-union, in association with bone loss, causing dysfunction and deformity.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams and Wilkins Company).

RUPTURE OF THE LOWER LUMBAR INTERVERTEBRAL DISKS

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FIFTEEN years ago in most of our Marine hospitals there was always a small group of patients suffering from a condition which we termed "chronic sciatica" or "chronic sciatic neuritis." There was no specific therapy for this affliction, and it was treated with rest, traction, back supports, physiotherapy, manipulations and various injections in the region of the sciatic nerve. Under this régime some improved but others continued to suffer in spite of all treatment. Some were forced to resign themselves to a life of chronic pain and invalidism.

In 1934, Mixter and Barr¹ presented their classical studies on protrusion of the intervertebral disks as a cause of low back and sciatic pain. The results of this work and later contributions by others have led to a better understanding of sciatic pain. We now believe that primary sciatic neuritis is rare and that chronic sciatic pain is usually produced by a ruptured intervertebral disk.

The ruptured disk syndrome is frequently described as a low back pain with sciatic radiation. While this description is essentially correct, the low back pain has frequently been allowed to dominate the picture. The pain is a nerve root pain with radiation over one of the dermatomes of the sciatic nerve. The causes of low back pain are many and in our experience the percentage due to ruptured disks is small. Less than one patient in fifteen admitted to this hospital for low back pain has findings consistent with a ruptured intervertebral disk. There is little justification for the diagnosis where low back pain exists without sciatic radiation.

PATHOLOGY

The intervertebral disk is composed of a tough, outer fibrocartilage with a soft central portion, the nucleus pulposus. Rupture of the fibrocartilage occurs rather constantly in the posterior and lateral portion at the point where the emerging nerve root crosses the disk. A portion of the fibrocartilage is extruded beneath the posterior longitudinal ligament and may rupture through the ligament to lie in direct contact with the nerve root. The extruded mass of fibrocartilage is forced backward and compresses the nerve root against the lateral margin of the ligamentum flavum. The nerve root is sometimes flattened and may show considerable swelling and inflammatory change. (Fig. 1.)

Approximately 90 per cent of all ruptures occur at the fourth or fifth interspaces.

There is some evidence to show that a partially protruded disk may be replaced by manipulation.² Such replacement is certainly impossible after the protrusion becomes complete.

SYMPTOMATOLOGY

A careful history will sometimes elicit a story of repeated attacks of low back pain preceding the onset of sciatic pain; but the sciatic pain may develop with no previous history of backache. It is conceivable that in the early stages of rupture, before nerve root pressure occurs, some back pain might be caused by the local damage and inflammation at the rupture site. Once pressure on the nerve root develops other symptoms are largely submerged. The pain

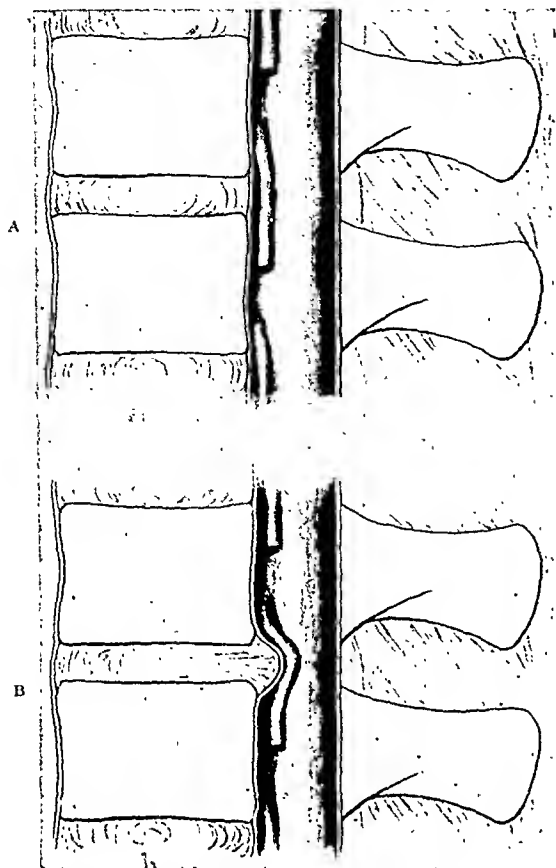


FIG. 1. A, lateral view of spinal cord lying in the bony canal (diagrammatic). The normal relationship of the nerve root to the intervertebral disk is shown. B, here is a moderate protrusion of a ruptured disk pushing the nerve root posteriorly. The ligamentum flavum against which the nerve root would be compressed is omitted for clarity.

most frequently radiates into the hip or sacro-iliac region. It is this characteristic, the radiation of the pain into the posterior hip, which in the past has commonly led to the diagnosis of sacro-iliac strain. Sacro-iliac strain is now considered a very rare injury, but the diagnosis was quite common only a few years past. The radiation of pain from a ruptured disk may stop at the hip or continue into the leg or foot. A most important diagnostic point is that the pain does not involve the entire sciatic nerve distribution as would occur from a peripheral neuritis. It involves one nerve root and symptoms are confined to this one dermatome. The most commonly involved root is S_1 caused

by a ruptured disk at L_5 . The pain commonly radiates to the heel, small toe or lateral surface of the foot. If rupture occurs at L_4 , the pain may radiate down the lateral surface of the leg to the middle toes or occasionally the great toe. Anesthesia or numbness on the lateral surface of the leg is common in ruptures of both L_4 and L_5 . An exaggeration of pain on coughing, sneezing or sudden strain is usually noted. Motor weakness is sometimes present in the calf or hamstring muscles. More than one nerve may be involved in the large disk protrusions and actual paralysis may exist.

The patient usually sits on the unaffected buttock. Bending or straight leg raising causes an exaggeration of pain. The pain is usually persistent in all positions, but lying is somewhat more comfortable than standing or sitting.

Exacerbation and remissions are characteristic of the disease. The cause of such cycles is not well established, but it seems probable that inflammatory swelling in the region of the protruded mass plays some part. The occasional relief afforded by spinal fixation, traction or chiropractic manipulations is perhaps due to replacement of a partially protruded disk.

DIAGNOSIS

Pain is the outstanding characteristic of the ruptured disk syndrome. Pain is out of all proportion to x-ray or physical findings. A careful history is therefore essential. A history of injury is present in only 50 per cent of our cases. Following a twisting strain there is sensation of a "slip," or something giving way in the lower back; or symptoms may begin as a vague pain which gradually radiates into the posterior hip and which becomes increasingly severe. Occasionally, pain begins in the lateral calf or foot without hip or back pain. The pain is exaggerated by coughing, sneezing, straining or lifting. There is a tendency to spontaneous remission with or without treatment, but in

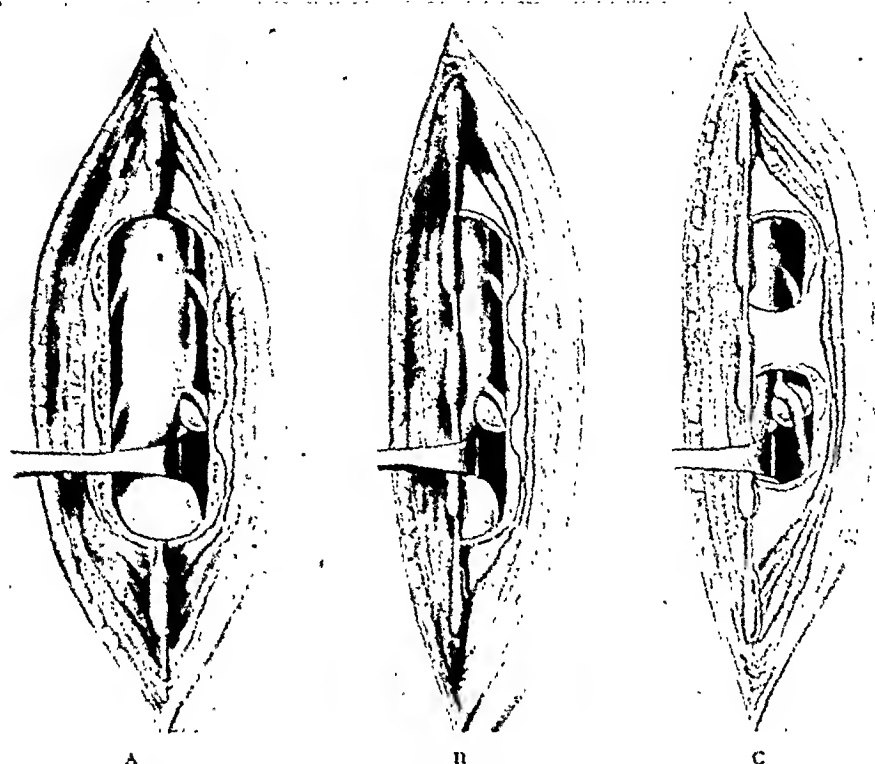


FIG. 2. A, the original operation for removal of ruptured intervertebral disks. The lamina and spinous processes were removed to provide wide exposure. Some spinal weakness always followed. B, hemi-laminectomy, a modification of the original operation, in which half of the lamina and all of the spinous processes were preserved. Adequate exposure was provided, but some spinal instability often followed. C, the operation which is now used. The ligamentum flavum is removed from between the lamina on one side. A small portion of the lamina is usually trimmed away above and below. Adequate exposure is obtained and the stability of the spine is preserved.

the more severe cases the pain never entirely disappears.

Physical examination usually shows some decrease in the achilles reflex, diminished sensation along the lateral surface of the leg and ankle, and slight atrophy of the calf muscles. The knee jerks are seldom affected, but secondary atrophy in the quadriceps muscle group is not uncommon. There is usually a list in the lumbar spine to the affected side. Straight leg raising on the side of the lesion is painful. Tenderness to percussion is sometimes present in the lower lumbar region directly over the rupture site.

Rarely there is pain and anesthesia bilaterally if the protruded disk is large, and causes pressure on the cauda equina. If neurological findings are present bilaterally, a tumor rather than a ruptured disk should be suspected. The classical

root pressure usually at L_4 or L_5 diagnosis should be made on a roentgen basis.

X-ray studies are of value in the primary disease of the vertebrae and structural abnormalities. The roentgenograms sometimes show narrowing at the interspace, but in general are more negative than positive in the diagnosis. Myelography is useful in the diagnosis and should be used rarely unless the diagnosis is obscure or tumor is suspected. Radiopaque oils are difficult to remove from the spinal canal and myelography is sometimes misleading. Where a laterally placed rupture exists, myelography may be negative and may actually rather than clarify the picture. If radiopaque oil is used, pantopaque possesses the advantage over lipiodol in being easier to remove from the spine.

FIG. 3.

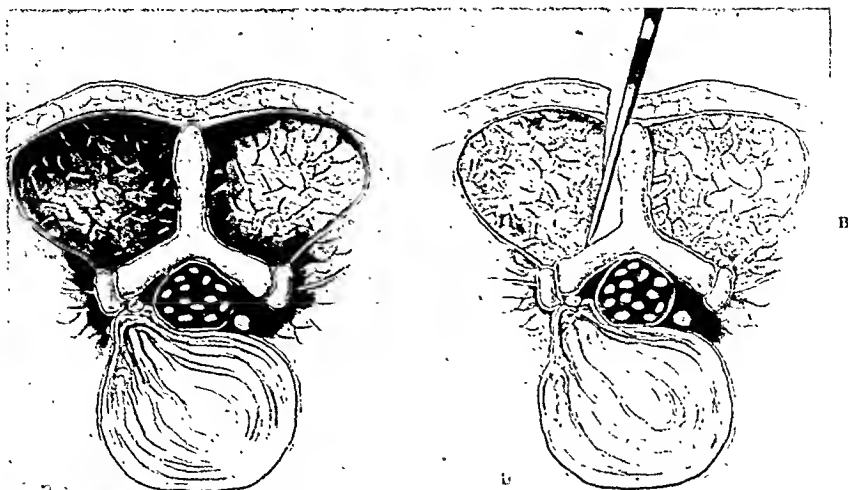


FIG. 4.

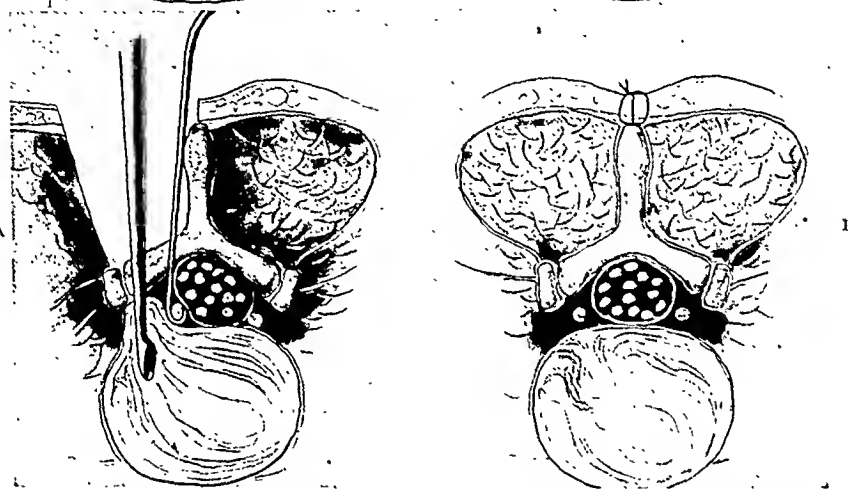


FIG. 3. A, sagittal section through lumbar spine. A ruptured intervertebral disk is shown compressing the nerve root on the left. The normal position of the root is shown on the right. The ligamentum flavum is omitted for clarity. B, method of subperiosteal dissection of lumbar muscles and fascia.

FIG. 4. A, the lumbar muscles have been retracted laterally, the nerve root and dural sac retracted medially, and a curette has been passed down into the intervertebral space. B, the protruding portion of the disk has been removed, together with the degenerated central fragments. The nerve root now lies free.

of more value than x-ray plates alone. To achieve maximum information the oil should be gravitated up and down the spinal canal under fluoroscopic observation and spot films made when a filling defect is noted. After diagnostic studies are completed the iodized oil should always be removed.

TREATMENT

The treatment of a ruptured intervertebral disk should be conservative unless the pain and disability is of sufficient severity to warrant operation.

Undoubtedly there are many cases of mild protrusion which have subsided under the usual régimes of rest, physiotherapy and lumbar supports. Such measures should be tried on all patients during the first attack. When attacks are recurrent and severe, operation is the only method of affording permanent relief. The relief is frequently spectacular. Many patients on the day following operation volunteer the information that the sciatic pain has completely disappeared.

The operation itself has been greatly modified over a period of years. In the

beginning a wide removal of two or three lamina was considered necessary. (Fig. 2A.) Considerable back weakness always followed such a procedure unless a spinal fusion was also done. Later the operation was reduced to a hemi-laminectomy in which the spinous processes and articulations were not disturbed. (Fig. 2B.) Back weakness was not so noticeable after this modification was instituted.

In the operation which is now used the ligamentum flavum is removed from between the lamina and only a small portion of the lamina above and below the lesion is trimmed away. The nerve root is retracted, the protruding portion of the disk removed and the intervertebral space is thoroughly curetted. If there appears to be developmental or congenital weakness or excess mobility present, the articular facets are also thoroughly curetted and bone shavings turned down from the lamina and spinous processes. There is abundant evidence to show that after such an operation the spine instead of being weakened is stabilized by fusion between the vertebrae. The patient is usually out of bed in seven to ten days and returns to work in four to six weeks. (Figs. 2C, 3 and 4.)

During the past seven years, we have operated upon one hundred patients for ruptured intervertebral disks. The diagnosis has been confirmed in ninety-one cases. Eighty of the patients in the proven cases have been completely relieved of all sciatic pain. Results in the others have varied from none to almost complete relief. Strangely enough of the nine cases in which no evidence of a rupture was found, three of the patients have been relieved of their pain. There has been little in our experience to justify such diagnoses as hypertrophied ligamentum flavum, concealed disk or disappearing disk. A rup-

tured intervertebral disk is as readily demonstrable as a ruptured appendix, and unless it can be demonstrated the diagnosis is unwarranted. The three patients who had no ruptured disk yet obtained relief from operation undoubtedly were suffering from nerve root pressure which was relieved at operation. Nerve root pain is occasionally due to spondylolisthesis, bony spurs of arthritic origin and developmental or traumatic defects. Such causes are in the minority and a ruptured disk is the most probable cause where the pain is unilateral, chronic and of great severity.

SUMMARY

1. Some of the more recent concepts in the diagnosis and treatment of ruptured intervertebral disk are presented.

2. Only a small percentage of patients suffering from low back pain have findings consistent with this diagnosis.

3. Myelography has largely been eliminated in the diagnosis and a neurological approach has been adopted, based on evidence of unilateral, single nerve root pressure.

4. Operation should be reserved for those cases in which conservative treatment has failed. The operation itself has been simplified and the period of disability greatly shortened during the past few years.

5. In properly selected cases the results from operation are gratifying and a return to full duty is usually possible.

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ADVANTAGES OF THE GRIDIRON INCISION IN THE TREATMENT OF CARBUNCLES*

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CARBUNCLES are relatively common infections which present a surgical problem of major importance. The severity of these lesions is often augmented by complicating conditions such as diabetes, nephritis and arteriosclerosis. These complications, especially diabetes, have a markedly adverse effect on the healing, morbidity and mortality of such cases.

In the effort to reduce morbidity and mortality and to speed up healing, a great many methods of treatment have been advocated.¹⁻¹² The mere fact that new methods are being evolved constantly implies that there is room for improvement in our armamentarium.

In 1930, one of us (U. M.) suggested a gridiron incision in the treatment of carbuncles in the diabetic. It was observed that despite the type of treatment used, practically all patients developed a central slough which finally became detached, leaving an area which required either a prolonged period for re-epithelialization or the application of skin grafts. It was recalled by the senior author that as an intern he had seen the late F. W. Parham use the gridiron incision and it seemed that healing was much more prompt in such cases.

In the original paper¹³ the treatment of carbuncle and diabetic gangrene was discussed. It was pointed out that the basic, underlying pathology of both conditions was quite similar. A spreading thrombophlebitis is apparent in both instances. The "line of demarcation," which is the line of ulceration that separates the living from the dead tissue, can be seen if the patient lives long enough. In the localized

gangrene of a carbuncle, there is always a deep red line with a white area just within this line. This line on section shows considerable leucocytic and round-celled infiltration which acts as a real barrier to a free circulation in the inflamed area. With the idea of liberating this constriction and improving the circulation so as to leave a minimum of slough, the use of multiple longitudinal incisions was adopted. We believe the end results in a series of carefully observed patients warrants the presentation of this method of treatment.

When a victim of a carbuncle is first seen, if the carbuncle is large, as many are, the patient seems to be a rather sick individual. The infected area is swollen and very painful, with a number of small openings discharging a very insignificant amount of pus. There is usually some fever and constitutional reaction to the infection. If he is a diabetic, treatment has to be instituted promptly both locally and constitutionally. Diet and insulin are both used as indicated, but we all realize that control of the diabetes is not easy when a patient is running fever. This factor is as a rule promptly controlled when adequate drainage is established, and the elevated temperature reaches normal. Very frequently patients who have required large doses of insulin may be stabilized with attention only to diet once they have become free of fever. This same principle has been found to hold in diabetic gangrene. In fact, temperature elevation as well as time element have always had some prognostic significance in these cases.

With a fever up to 102 or above in either diabetic gangrene or carbuncle we have

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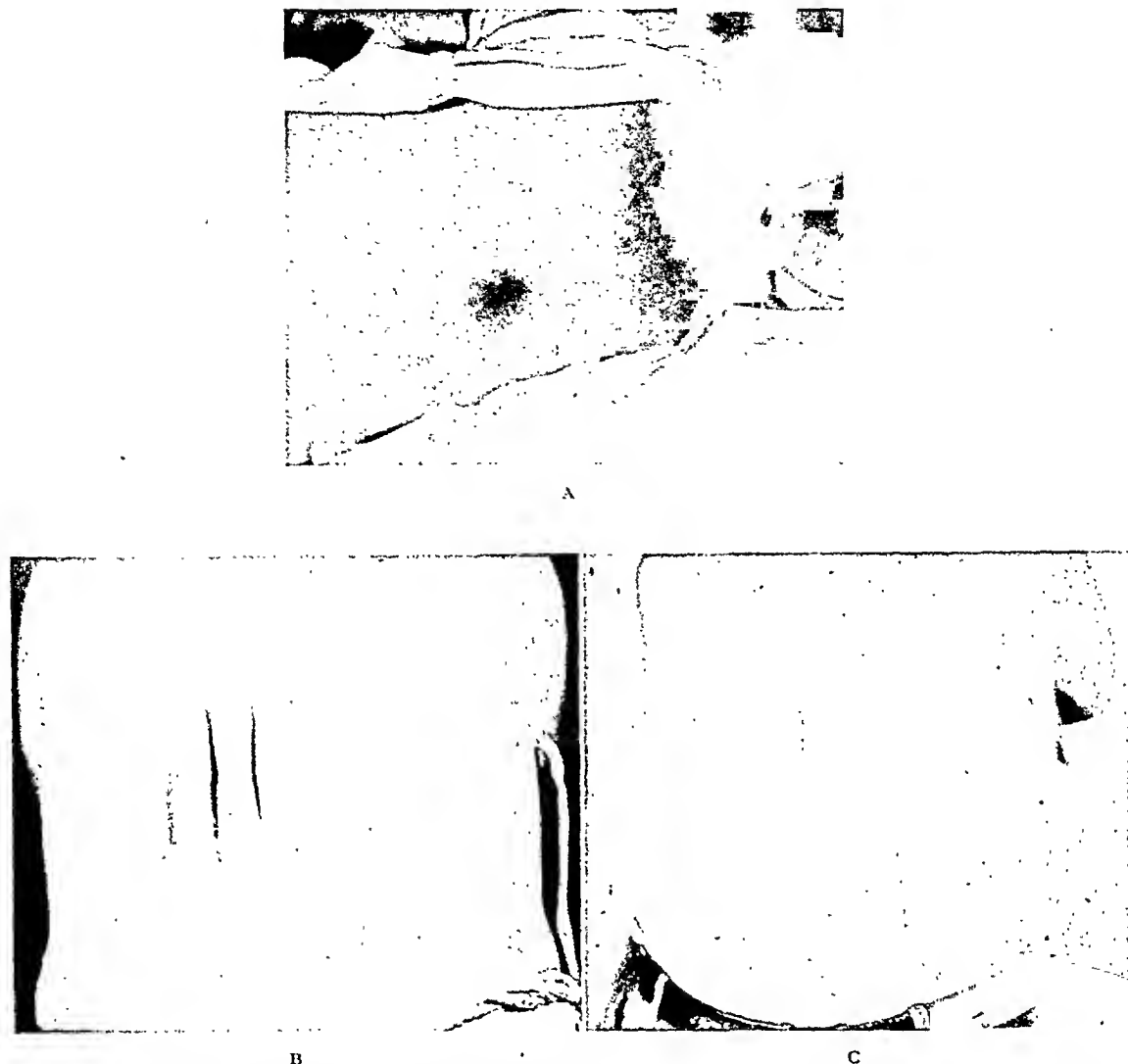


FIG. 1. A, original lesion; moderately sized carbuncle on back. B, gridiron incision fourteen days later. Note clean appearance with evidence of healing; C, incisions healed in six weeks.

learned to give a guarded opinion as to outcome. It has been stated that insulin loses 50 to 75 per cent of its efficiency in the face of temperature elevation. This means that the diabetic with an infection has a double burden to bear and must be promptly, energetically and intelligently treated. The dual burden can be borne only for a limited time.

In caring for carbuncles especially in diabetic patients, anesthesia is an important consideration. Local anesthesia seems obviously contraindicated. Ethylene has been our choice in most instances, or cyclopropane may be used. The operative procedure is brief. We can thus avoid the use of ether to which there are the usual objections.

OPERATIVE PROCEDURE

1. Multiple longitudinal incisions are made about 1 to 1½ inches apart. The incisions must extend beyond the leucocyte barrier into normal viable tissue in order to prevent interference to circulation and to help maintain viability of the newly created skin bridges.

2. Bleeding as a rule is brisk but is easily controlled by gauze packing which is left in for twenty-four hours.

3. Wet dressings are applied to facilitate drainage.

4. Packing is removed in twenty-four hours and subsequent treatment has varied with the individual surgeon. Azochloramide irrigations or compresses, 1 per cent carbolyzed solution, sulfanilimide and dry

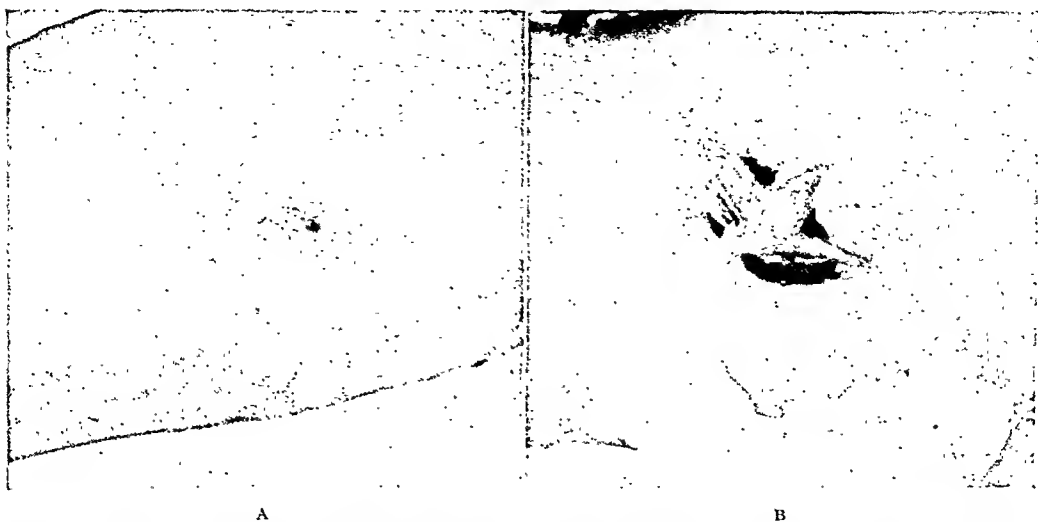


FIG. 2. A, original lesion; moderately sized carbuncle on back. B, cruciate incision twelve days later. There is no evidence of healing.

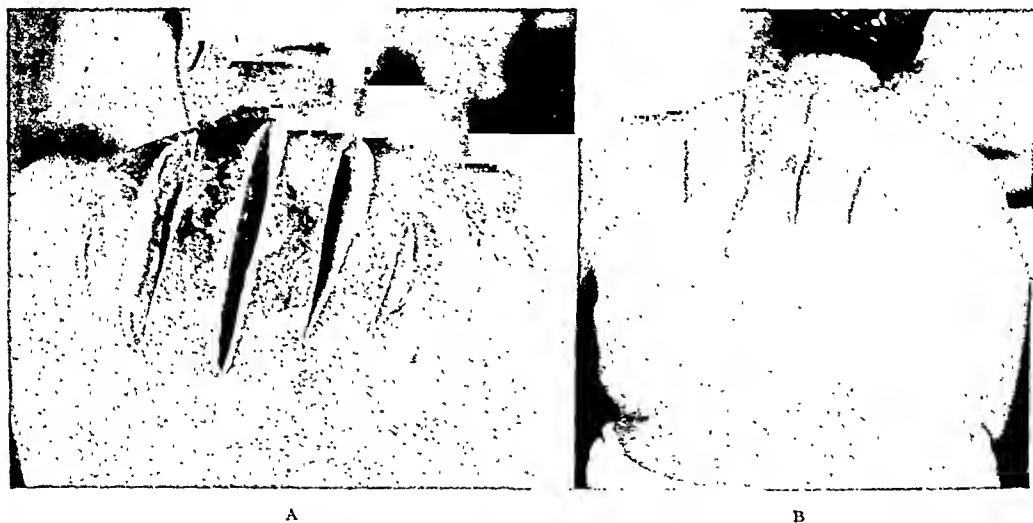


FIG. 3. A, gridiron incision forty-eight hours after admission and treatment of huge carbuncle. B, same incision ten weeks later showing almost complete healing with no tissue loss.

gauze, have all been used without any great difference being noted. When the original packing is removed, it is well to place small fine mesh strips of vaseline gauze between each of the incisions to prevent agglutination of the edges.

5. Penicillin is now a routine measure but has not been used long enough for a full evaluation of its benefits.

In the past five years we have observed 211 cases of carbuncle. Of this group 102 patients were treated by the gridiron incision and 109 patients treated by other methods. The average healing time in uncomplicated carbuncles treated by grid-

iron incision, that could be followed completely, was forty-three days, whereas fifty-six days were required for complete healing in similar cases treated by other methods. In diabetes and other complicated cases, the healing time was considerably prolonged. It is interesting to note that in general the carbuncles treated by the gridiron incision were larger than those treated in other ways. Despite this fact, the healing time was shorter. While this difference is not great, we believe it offers an advantage in the choice of methods for the care of these individuals.



FIG. 4. A, large carbuncle of back treated by means of gridiron incision. Photo taken forty-eight hours after admission; two skin bridges show signs of gangrene at the center. B, same patient ten weeks later; central area of two skin bridges has sloughed out; defect is closing up rapidly with a minimum of tissue loss and scarring.

The outstanding advantage of the gridiron incision is derived from the fact that there is a minimum amount of tissue loss and deformity. This can be shown best by pictures taken of actual cases. The three patients with large carbuncles shown in Figures 1, 3 and 4 were treated with gridiron incisions. For the purpose of comparison, Figure 2 shows a patient treated by means of a cruciate incision. The carbuncles pictured in Figures 1 and 2 were somewhat similar in size and location. However, when Figure 1B is compared with Figure 2B, the advantages of the gridiron incision are well demonstrated. Although the time element is approximately the same in both cases, the healing is progressing more rapidly in the former. The multiple incisions are closing with a minimum of scar and tissue loss, whereas the cruciate incision gives no evidence of healing.

Figure 4 shows a patient who applied for treatment after several weeks of self-therapy. The central area of the carbuncle was gangrenous when the incision was made. This caused a slough in two skin bridges. Nevertheless, healing has progressed rapidly, and the defect is closing with a minimum of tissue loss. The results

obtained in Figures 1 and 3 can be expected when necrosis of the skin does not occur. It is well known that extensive tissue slough and skin necrosis take place when carbuncles are allowed to go untreated too long a time. Early drainage of these lesions cannot be stressed too highly, because it plays an important rôle in the ultimate viability of the skin bridges. This is especially significant in patients who are diabetic.

The mortality figures in this series of 211 cases are of interest. There were no deaths in 127 uncomplicated cases of carbuncle, regardless of the method used in treatment. However, in the forty-seven complicated cases treated by the gridiron incision, there were six deaths with a mortality rate of 12.7 per cent. In the thirty-seven complicated cases treated by other methods there were three deaths with a mortality rate of 8.1 per cent. Statistically, this difference is not significant. The overall mortality rate for 211 cases was 4.3 per cent. Table 1 gives an analysis of the deaths in this series. We believe that it is especially important to note that six of the nine deaths occurred in patients with diabetes. This serves to reemphasize the serious prognosis in these cases. The

4.3 per cent mortality figure is too high, but until we educate our patients to apply for earlier treatment we will be working under a handicap.

TABLE I
ANALYSIS OF DEATHS

Case No.	Cause of Death	Type of Treatment
87	Diabetes—coronary occlusion	Gridiron incision
62	Diabetes—cardiac failure	Gridiron incision
63	Diabetes—uremia	Gridiron incision
73	Diabetes—bronchopneumonia and meningitis	Gridiron incision
81	Diabetes—pernicious anemia and heart disease	Gridiron incision
85	Septicemia	Gridiron incision
175	Diabetic coma	Conservative Management
210	Septicemia and brain abscess	Single incision
187	Psychosis—pulmonary collapse	Single incision

Mortality 4.3%.

On the basis of our study of 211 cases of carbuncle the advantages of the gridiron incision can be summarized as follows: (1) It provides for adequate drainage; (2) it creates viable skin bridges which act as grafts to cover the defect; (3) it heals with a minimum of tissue loss, scarring and

deformity; and (4) it requires fewer days for complete healing.

The authors are indebted to W. B. Stewart of the Art Department and J. H. Phillips for their invaluable assistance in photographing and collecting material.

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LATE REPAIR OF TENDONS IN THE HAND*

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MEN who work with machinery or who handle sharp objects are constantly subject to injuries of the hand. Thus, quite apart from combat wounds, military personnel sustain a large number of injuries to the tendons of the hand which parallel the injuries occurring in industrial accidents. The results of primary tendon repair are frequently disabled hands which require secondary operation.

RESULTS OF PRIMARY TENDON SUTURE

In spite of all that has been written about proper methods of primary tendon repair, errors are committed with such frequency that poor results are the rule rather than the exception following initial tendon suture. Suture of extensor tendons is most apt to give a good result while the repair of flexors is much less successful. Flexors which have been sutured at the wrist give the best results (Fig. 1) while the result of repair in the palm is not as good.

Primary suture of flexor tendons in the fingers still meets with failure at the hands of all but a few experts, and most of these cases result in disabilities which require late plastic repair. (Fig. 2.)

The reasons for poor results in primary tendon suture are: (1) anatomical, (2) bacterial, and (3) surgical.

Anatomical. The flexors are more powerful than the extensors and thus overcome adhesions which form about the extensor tendons. In a large measure this accounts for the ease with which function returns to repaired extensor tendons. In addition, the absence of tendon sheaths about the extensors, except beneath the

carpal ligament, allows more ready movement of a repaired tendon in the areolar tissues. One further anatomical point predisposing to good extensor function is the "straight-line" pull of the extensor tendon over the dorsum of the metacarpals. The extension of the digital portion of the extensors is so coordinated with the action of the lumbrical and interosseus tendons that considerable movement is often possible by compensatory action of these small tendons when the extensor is adherent.

The flexor tendons show only slight differential motion at the wrist, differentiating into more individually functioning tendons in the palm, and supplemented to a considerable degree by the lumbrical muscles. Thus, acting as a unit, they can still give good function although they are considerably scarred. (Fig. 1.) Aiding their return of function, following primary suture, are the flexors and extensors of the wrist which are powerful and tend to stretch adhesions in the flexor tendon compartment at the wrist. The tendon sheaths at the wrist are more gross structures and do not sharply circumscribe an individual tendon as they do in the fingers. The pull of the flexor muscles is again exerted in a "straight-line" at the wrist so that all of the muscle power can act directly on the adherent portion of the tendon, loosening binding adhesions.

In the palm, adhesion of a flexor tendon following primary repair is more disabling because motion of the tendon is in exact proportion to the degree of flexion of the individual finger. The pull of the flexor muscle is nearly straight; but when the

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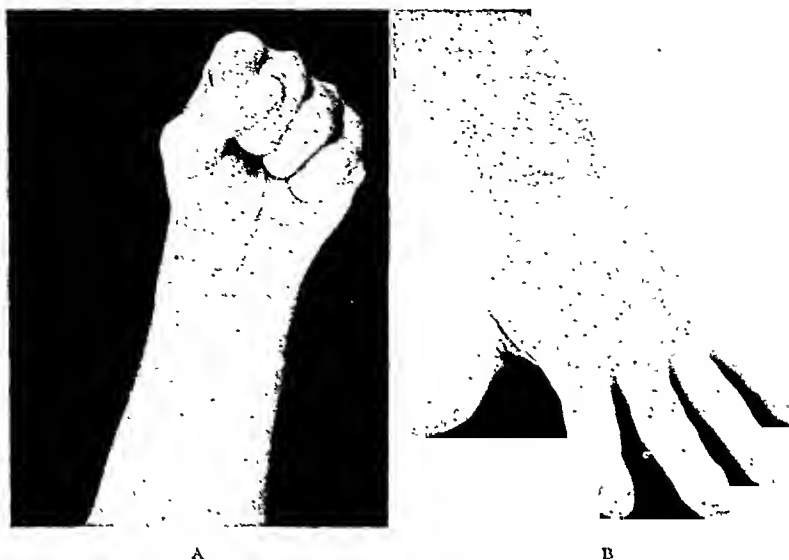


FIG. 1. Patient C. Result three months after primary suture of flexor tendons at the wrist following a self-inflicted gunshot wound (.45 calibre) which passed completely through the wrist, tearing tendons to shreds. Although much scar tissue undoubtedly followed this repair, the result is excellent.

wrist is flexed, power of the muscle is diminished where it pulls through the angle of flexion. Thus, there is not quite so much force exerted on the adherent tendon when the wrist is flexed. There are no tendon sheaths in the palm except for the little finger and the thumb and distal to the distal palmar flexion crease for the tendons of the index, middle and ring fingers. Repaired tendons, then, glide in the areolar tissue which surrounds them.

In the fingers and thumb, the tendon must "pull around a corner" and is thus equipped with a gliding synovial sheath and lies in a firm tunnel of unyielding connective tissue. Primary repair of a tendon within these tunnels is followed by swelling of the tendon and, since the tunnel is unyielding, necrosis of the tendon occurs. The result is replacement of the tendon by scar and no function can take place. If the sublimis tendon is removed and only the profundus is repaired, and in addition the tunnel is split along its side or unroofed over the tendon suture line, necrosis does not occur but some adhesions always form. The pull of the flexor muscle, since it must pull through an angle, is never as effective in overcoming adhesions as it is in the palm and wrist.

Bacterial. Tissue reaction to the initial injury and the surgical repair is greatly magnified by bacterial contamination. Koch has emphasized the necessity for covering the wound with a sterile dressing as early as possible to prevent further contamination of the wound with bacteria from the nose and throat of those who examine the wounds. The first six hours after injury have been considered the period of maximum safety, and repair after this time has been felt to be contraindicated. With the use of systemic chemotherapy with sulfadiazine and penicillin, it has been found safe to undertake some repairs at a longer period after injury, up to twenty-four hours. Nevertheless, this extended time period should be utilized only for extensor tendons or for flexor tendons severed at the wrist or in the palm.

Thorough soap and water cleansing of the entire hand and forearm, careful débridement of dirt and devitalized tissue and good skin preparation, added to the strictest aseptic technic in the operating room, will reduce bacterial contamination, and careless, haphazard attention to these procedures will increase bacterial contamination and produce a poor result.

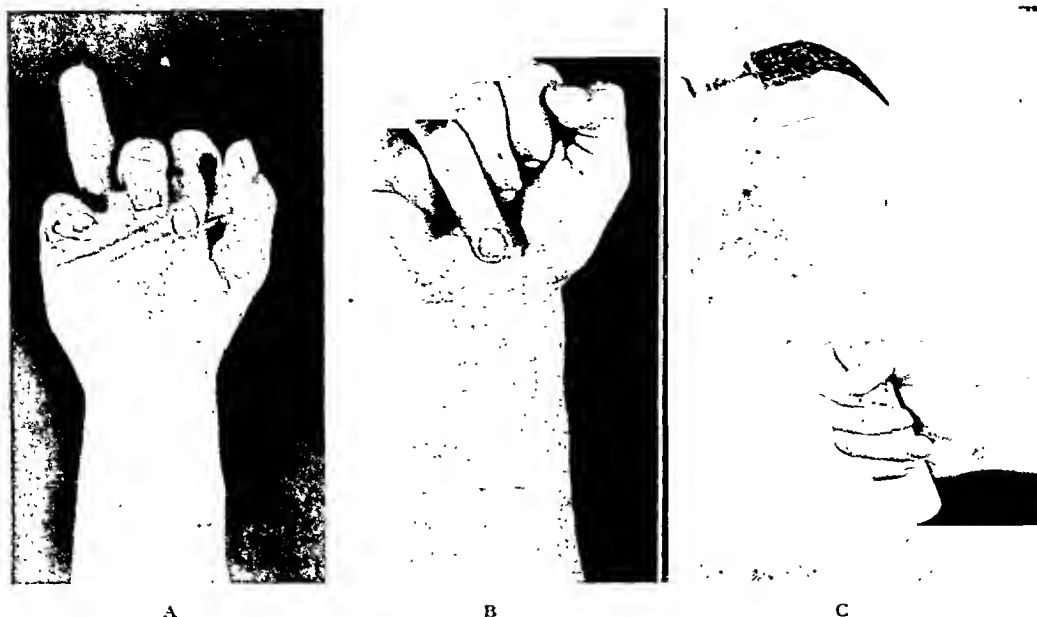


FIG. 2. Patient E. A, unsuccessful result following primary suture of flexor tendons of the right ring finger performed elsewhere. The affected finger is inflexible except for the metacarpophalangeal joint, which is moved by the lumbrical and interosseus muscles B, result three months after total replacement of the scarred flexor tendons by a tendon graft. There is good movement in the proximal interphalangeal joint, but the terminal phalanx does not flex. C, result at eighteen months; good function has been restored but perfect flexion into the palm is still not possible.

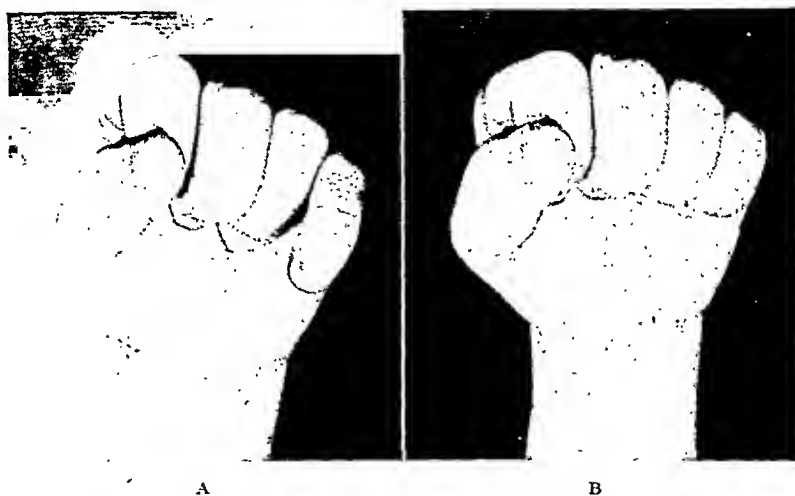


FIG. 3. Patient W. A, preoperative limitation of flexion of little finger due to adhesion of the sublimis tendon within the tendon sheath at the level of the proximal phalanx. B, result following excision of both sublimis and profundus tendons and replacement with a tendon graft from palm to finger tip. Such a complete return of function, with extreme flexion of the terminal phalanx, is the exception rather than the rule in tendon grafting.

Surgical. The causes of failure in primary suture of tendons in the hand are all too often due to poor surgery. The errors extend all the way from poor surgical judgment of the patient's general condition to failure in the many minute details of surgical technic which have been so liberally discussed in the surgical literature for many years, especially by Bunnell, Koch

and Mason. Wrong incisions continue to be a major cause of crippling deformity. Unnecessary trauma at operation, use of too gross suture materials, operating in a bloody field without a tourniquet, inadequate suture technic and too early motion are but a few of the faults responsible for non-functioning primary tendon repairs, so that on the surgeon himself



FIG. 4. Patient B. A, limitation of all motion of index finger due to severed flexor tendons at the base of the finger. B, function one year following total excision of scarred tendons and replacement by a tendon graft. Flexion is almost complete.

must fall the responsibility for many failures. In all fairness, however, it should be stated that in a good number of cases, in spite of the application of the very best judgment and skillful technic, failures can and do occur.

LATE TENDON REPAIR

If no initial surgery has been performed and the wound has been closed per primum, or if initial surgery has been skillful and gentle, yet a non-functioning result has occurred, the chances of obtaining a good result from late repair are best. If infection has occurred, foreign bodies have remained in the wound or multiple surgical procedures have been performed, with resultant fibrosis, late tendon repair offers only a fair chance for recovery of function. If fingers have been ruthlessly opened by the primary operator, cutting across flexion creases at right angles and destroying the "pulley" mechanism in the fingers, little hope can be given for restoration of function to a normal state. A moderate number of these cases can be improved by excision of all volar scar and replacement with a pedicle flap of skin and fat, beneath which a tendon graft can glide, but results in these prolonged operative repairs are none too good, even in the hands of the most skilled operators.

Fingers in which joints are stiff, nerves are severed and other serious defects are present should not be considered suitable for late tendon repair. If the defects cannot be corrected by splinting, exercise, physiotherapy or surgical interference, the offending fingers should be amputated and the hand revised to make the most of its remaining functional parts. Many a patient, reluctant at first to part with a crippled digit of this type, begs to have it amputated after a trial at work.

A hand with flexible joints, intact nerves and good circulation presents the ideal situation for late tendon repair, and improvement almost always follows plastic reconstruction. If all such cases are analyzed on a purely objective basis, however, it must be admitted, even by the strongest advocates of tendon surgery, that excellent results, with absolutely perfect return of function, are rare indeed with flexor tendons. (Fig. 3.) If a useless digit is converted to a useful one, if the strength of grip is returned to normal and if the capacity of the hand for useful work approaches normal, the patient is greatly pleased and the operator should consider his repair successful. (Figs. 2, 4 and 6.)

A final evaluation of results should be deferred for a year to eighteen months

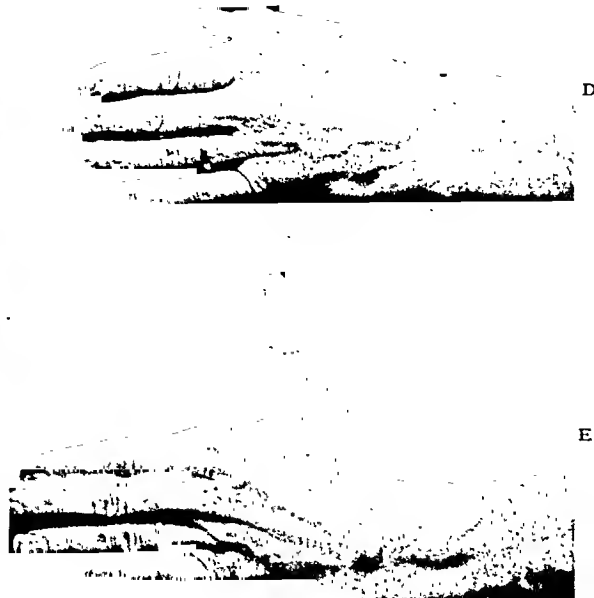


FIG. 5. Patient H. A, appearance of thumb at operation for the late repair of a severed extensor pollicis longus. There was complete inability to extend the terminal phalanx. B, transverse incisions used for insertion of a tendon graft from the palmaris longus tendon. C, plaster splint used to immobilize the grafted tendon following repair. D and E, end result three months after operation. There has been complete return of function.

before any case is called a failure. Tendons, like bones, align their structure in the direction of the stress which is put upon them, and often a finger which flexes poorly at three months will be improved at six months and with active exercise it may be moving well six months to a year later. Premature re-exploration of an operated finger may forfeit all chance of final improvement. (Fig. 2B and C.)

Technic. The sterile, healed hand which needs late repair presents the surgeon with an immaculate, well nourished complex interior. His knowledge of anatomy should be absolute. His background of surgical

training and experience should be great enough to cope with any surgical complexity which may arise. Meticulous skin-preparation and aseptic technic must, of course, be flawless, and the surgeon should approach the tissues with positive clarity of purpose, yet maintain an artful delicacy in all his movements.

A bloodless field, secured by a pneumatic blood-pressure cuff tourniquet about the upper arm, gives necessary visibility and has made possible all successful surgery of the hand. Although some authors have repeatedly left tourniquets in place for several hours, it seems more in keeping



FIG. 6. Patient O. A, preoperative view of crushed right hand with adhesion of all extensor tendons as well as total loss of function of the flexors of the little finger. B, postoperative result one year following complete release of extensor adhesions, repair of malunited metacarpals and tendon graft to the flexors of the little finger.

with basic laws of cellular physiology to allow a "rest period" of ten minutes out of every hour during which the tourniquet is deflated and normal circulation is restored. At the end of this time the arm is elevated for a few moments and the tourniquet is re-inflated.

Incisions should be thoughtfully planned, keeping in mind the exposure necessary for the particular tendons involved and the necessity for conformation with the normal folds and flexion creases of the skin. Extensor tendons can be repaired through two or more transverse incisions, conforming to the normal skin lines of the dorsum of the hand. (Fig. 5.) Flexor tendons are exposed in the fingers through mid-lateral incisions, which lie dorsal to the digital nerves and vessels, and in the palm through a broad based palmar flap, the margins of which coincide with or parallel the flexion creases. Supplementary incisions in the wrist are made transversely when necessary.

Scars on the surface of the hand may alter elective lines of incision and one must be prepared to utilize a thick-split skin graft for closure, if necessary, where scars have been removed. If scarring is extensive, preliminary skin-grafts should be done at a separate operation, using pedunculated flaps of skin and fat when the scar directly overlies a damaged tendon.

All deep scar should be removed, but careful preservation of tendon sheaths should be maintained, if at all normal. Opening the sheath from the side permits preservation of the volar gliding surface. In the wrist, excision of excessive scar alone is frequently all that is necessary to give a good result. In the palm and in the fingers the sublimis tendon is routinely excised and reparative efforts concentrated on restoration of the profundus tendon alone. The long flexor of the thumb is treated as if it were a profundus tendon, which, in effect, it is.

Extensor tendons are exposed and repaired by simple approximation, if possible. Retraction of tendon ends is rarely encountered in the fingers, but moderate retraction is to be expected where the extensors overlie the metacarpals.

A segment of palmaris longus tendon is flat and approximates the size of the extensors. Thus, it makes an ideal graft for the shortened tendons. The long extensor of the thumb retracts much farther than those of the fingers when they are severed, and hence almost always requires a tendon graft. (Fig. 5.)

An alternative method is a tendon transfer from the extensor carpi radialis brevis tendon. Adhesions of the extensor tendons to the underlying metacarpals must be freed and occasionally insulated by free

fat grafts to prevent re-adhesion. Concomitant mal-union of metacarpal fractures should be corrected at the same time. (Fig. 6.)

Flexor tendons are repaired by direct approximation in the wrist and hand, whenever possible, flexing the wrist during healing and relying on later active exercise and stretching to restore normal functional length of tendon. If retraction of the proximal tendon end is very great, a tendon graft is always used.

In the fingers, flexor tendon repair is almost always performed by the use of a tendon graft. The basic principles behind tendon grafting for such defects are so thoroughly emphasized by Bunnell that his writings should be thoroughly studied by all who intend to practice tendon grafting.

Severed nerves should be repaired by freshening and approximation whenever possible. Free nerve grafts from the sural nerve in the leg are used with success in a moderate number of cases.

Closure of the wounds should be accomplished without buried sutures in the subcutaneous tissue, to minimize foreign body reaction, and the skin edges should be carefully approximated. Pressure dressings of evenly distributed, fluffed gauze assure the best conditions for healing. Splints are used to maintain a relaxed position for the tendons. (Fig. 5.) Plaster of Paris bandages provide the most universally useful splints; but metal splints, made individually before operation, are sometimes used and have the advantage that they can be boiled and applied to the hand while the wound is still open, whenever this is desirable. In the case of combined osteotomy and tendon repair, it is very helpful to be able to check the position of the bony fragments before the wound is closed and it is known that the position will not change throughout the healing process.

When the patient is returned to bed, the arm is elevated on three pillows to aid

venous and lymphatic return. Circulation can be checked easily if finger-tips are left exposed when the dressing is applied. The first dressing of the wound is usually left until the eighth or tenth day, at which time all sutures are removed.

After-care. Although temptation on the part of both surgeon and patient may be great, movement of the repaired tendons before three weeks should not be permitted. Mason and Allen so conclusively proved the length of time necessary for healing, that there should be no question of earlier movement. Active exercise alone should be allowed from the fourth to the sixth postoperative weeks, after which time both active and passive exercise, physiotherapy and massage may be used vigorously, but always within the limits of tolerance of the patient.

If initial motion is unduly slow to return, a finger can be started into flexion by traction. This can be accomplished with a metal forearm splint with an "outrigger" of rigid wire rod, bent to obtain a pull in the proper direction. A leather stirrup or an old glove can be used to grip the finger and this can be removed periodically for active exercise and physiotherapy. It is our impression that fixed traction, with inelastic cord, is better than the use of elastic traction with rubber bands. The firm, fixed traction is made tighter each day, and the gradual steady traction does not produce the soreness and stiffness in the interphalangeal joints which is so common with elastic traction.

Time and willing cooperation on the part of the patient are the major factors in obtaining successful results in late tendon repair. A patient must be willing to utilize force, even though it hurts a little. He must be patient enough to spend tedious hours of active exercise and he must not be discouraged by the sometimes snail's pace to recovery. When all of these conditions have been satisfied the surgeon will have reconstructed, in a slight degree,

the wonder of the gliding mechanism in the finger.

are to be obtained. Good results are frequent, but excellent results are rare.

CONCLUSION

Late repair of tendons in the hand is necessary because primary repair is often unsuccessful. The reasons for poor results of primary suture are anatomical, bacterial and surgical. Cases in which late repair is contemplated must be carefully selected. Details of technic and after-care are important, but also the cooperation of the patient must be excellent if good results

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If an extensor tendon is severed, a simple yet practical method is to suture the cut ends with stainless-steel wire, the same suture being made to unite the skin as well. Adequate splinting will prevent the tendon ends from pulling apart.

From "Minor Surgery" edited by Humphry Rolleston and Alan Moncrieff (Philosophical Library).

SPLENECTOMY IN FAMILIAL HEMOLYTIC JAUNDICE*

STUDY AND CURE OF PATIENT WITH NORMAL ERYTHROCYTE FRAGILITY AND OTHER UNUSUAL FEATURES

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FAMILIAL hemolytic jaundice has been recognized as an entity ever since its first accurate description by Minkowski¹ in 1900 when he emphasized the familial tendency of the disease. Its salient clinical and laboratory features are now so well defined that few errors of diagnosis occur. As early as 1887, Spencer Wells, of England, carried out the very first splenectomy for this condition without understanding its rationale. His patient was examined forty years later by Lord Dawson² and found to be well. Today, while the beneficial effect of splenectomy is widely recognized, the reason for the beneficial effect still remains somewhat obscure.

The etiology of familial hemolytic jaundice continues unknown. Some workers, including Haden³ and Naegaeli,⁴ have attributed the fundamental pathologic changes as being due to the production of an overly fragile microspherocyte in the bone marrow. They considered the splenomegaly, anemia and icterus as secondary to these abnormal cells. On the other hand, Doan, Wiseman and Curtis⁵ believed that the primary development of pathologic phagocytic action in the spleen, itself, causes secondary changes in the marrow and the erythrocytes. The ideas of Wiseman, Doan et al. seem more tenable to us since splenectomy affords complete cure, as many of the blood changes may persist for many years.

More recently, other important contributions as to the cause of these hemolyse have been suggested. Of these, one of

the most significant ideas is that of Damshak, Schwartz and Gross⁶ who conclude the following: (1) Isohemolysins of the immune body type were discovered in the serum of three cases of acute hemolytic anemia. (2) Anti-guinea pig hemolytic serum was prepared by the injection of guinea pig red cells into rabbits; this serum possessed all of the immunologic properties of the serum found in clinical cases. (3) Hemolysis of the red cells of the guinea pig *in vivo* followed the injection of the serum. (4) By varying the dosage of the anti-guinea pig serum, various types of hemolytic syndromes were produced, formulating hemolytic anemia with hemoglobinuria, acute hemolytic anemia, and subacute hemolytic anemia. (5) Various types of blood pictures could be produced at will—microspherocytosis, increased erythrocyte fragility, reticulocytosis and pseudomacrocytic blood pictures. (6) Their observations point to the conclusion that spherocytosis is due to the activity of hemolysin and not to an abnormal anatomic peculiarity or to a disturbed formation of cells in the bone marrow. Since increased fragility is the function of the increased thickness of the red cells, it is dependent upon the same cause. (7) They believe that hemolytic syndromes are due to hemolysin; possibly of different types and of course, in different amounts, functioning slowly in some cases and violently in others. The various blood pictures of the hemolytic anemia are in all probability due to the effect of varying activity of the hemolysis and modified by the individual variations. (8) Since the

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experimentally produced hemolytic syndromes and the numerous clinical types are closely comparable, the chief difference of the clinical syndromes may be a matter of the amount of functioning hemolysin present.

While the idea of a hemolysin in the serum being responsible for the acute hemolytic anemia is a very attractive one, it has not been borne out by other investigators.

It is of interest to note that two features of the disease, while generally recognized as being necessary to diagnosis, may be absent. They are, first, the presence of relatively normal indices of red cell fragility and second, the absence of reticulocytosis. We believe our case falls in the category of the former and represents one in which there is no appreciable alteration in red cell fragility, and yet has sufficient of the other important clinical findings to warrant a diagnosis of familial hemolytic jaundice as confirmed by the pathologist.

While the significance of the increased fragility of the red cell has been recognized as early as 1907, when Chaufford⁷ pointed out its presence, other recent investigators have shown that it may not be present and that normal fragility may occur. Bockus and Tuman⁸ state that while microcytosis and increased fragility are the most constant features of this disease, the fragility has been found to be normal in about 10 per cent of the cases. Gännslen⁹ expressed the same opinion, too, finding normal fragility in 10 per cent of his cases. Hurley and Moore¹⁰ reported a case with normal fragility and normal reticulocyte count cured by splenectomy. Similarly, Dawson¹¹ found normal fragility in five out of forty cases studied.

Another cardinal feature of the disease process is the presence of so-called microspherulosis. This was first described and its significance stressed by Naegeli.¹² Thompson¹³ states the opinion that spherical microcytes are as pathognomonic of this disease as sickle cells in sickle cell anemia. This opinion is open to controversy. It

can readily be understood why globular cells or spherocytes are more readily affected by hypotonic solution than a normal erythrocyte which is biconcave. This is based on the physiologic observation that when normal biconcave erythrocytes are placed in hypotonic solution they swell and become readily globular. Hence, if the cell is already globular, its tendency to increased fragility is readily understood. In physiologic experiments, Castle and Daland¹⁴ conclude the following: Differences in the susceptibility of various types of erythrocytes in hemolysis to hypotonic salt solution are due largely to differences in form and not to differences in osmotic behavior. Direct microscopic observations indicate that (1) hemolysis with a given type of erythrocyte is associated with the assumption of a spherical form in hypotonic plasma. (2) The more susceptible the erythrocyte to hypotonic hemolysis, the less hypotonic is the plasma necessary to cause the assumption of the spherical form.

Of additional interest is the relation of red cell diameter and fragility to hypotonic salt in various mammals. The following table of Vallery Radot¹⁵ is rather graphic (Table 1.)

TABLE 1

	Dia. of R.B.C. in Microns	Hemolysis Begins % Na. Cl. Sol.
Man.....	7.6	.42
Guinea pig.....	7.5	.44
Monkey.....	7.2	.44
Dog.....	6.6	.50
Rabbit.....	6.3	.52
Horse.....	6.2	.54
Rat.....	6.0	.54
Cat.....	5.6	.60
Goat.....	5.3	.72

From the above we can readily see that the smaller the cell the more easily it is affected by hypotonic solution of sodium chloride.

Apparently then the significant defect which forms the basis of familial hemolytic

anemia is the presence of microspherulosis. However, the direct etiology of the defect remains unknown at present. It has been shown, however, that the spleen itself is not responsible for the increased fragility because in many instances following splenectomy, the fragility index remains high. Despite this, however, splenectomy resulted in very distinct relief of our patient's condition as manifested by the return of the red blood cells to within normal limits, absence of icterus and clinical well being.

We believe then that this case represents the following unusual features: (1) Normal erythrocyte fragility, (2) presence of very few circulating microspherulocytes. (3) Cases with these characteristics are rather infrequent in the literature. We believe that this patient is a true case of familial hemolytic icterus and has apparently rapidly been cured by splenectomy.

CASE REPORT

W. A., a white male, age twenty-two, a mail clerk, was admitted to the hospital on March 19, 1945, with the following history: He stated that he was in relatively good health until October, 1942. At that time he noticed marked lassitude and weakness. He consulted a local physician who made the observation that he was jaundiced and also noticed that he had enlargement of his spleen. A blood count taken at that time disclosed the presence of anemia. Apparently, it was thought that he was suffering from pernicious anemia and consequently, his physician put him on intramuscular liver extract. He continued on this management for about a month with slow but apparently distinct improvement. Following this, he stated, the next month he felt much better and was able to return to work. He believed that the jaundice was still present but diminished. He then continued to work along until January, 1943, at which time he was inducted into the military service. He was able to carry on his regular routine army duties and was able to undergo basic training and continued along in army service until August, 1943, at which time he developed another episode of weakness with exacerbation of his jaundice. At this time he was hospitalized at the Station Hospital at Fort Bliss. Studies

there disclosed the presence of splenomegaly, anemia and jaundice. He was advised that he was probably suffering from a congenital type of hemolytic anemia, and it was suggested or recommended that he undergo splenectomy. He was discharged from the service at this time. Following discharge from the service, despite the absence of any specific therapy, he slowly improved, was able to return to work and then worked on and off for the next year or so until December, 1944. At this time he again developed a recurrence of his marked asthenia and lassitude. He was unable to stand very long. He was again studied by a local physician and was again advised to undergo splenectomy.

His past history was quite significant, particularly as respects his family history, as follows: His mother, it was said, suffered from chronic anemia with splenomegaly. She had been under management with liver extract for some time. A report of her peripheral blood study will be made subsequently in the course of this discussion. His father was living and well. The maternal grandmother was stated to have had a similar condition to that which existed in the patient's mother, i.e., jaundice with anemia. The exact origin of this was never evaluated. There were two brothers and three sisters living and well. However, one of the sisters had an anemia of unexplained origin. There was no apparent anemia or splenomegaly that had been noted in the sister. There was also a record of a blood cousin of the patient who is the son of a brother of the patient's mother; he was reported as having anemia and splenomegaly.

The patient had had the usual childhood illnesses. There were no other medical illnesses noted. He had had a tonsillectomy in childhood. There were no other operations noted and venereal disease was denied.

Examination revealed a fairly well developed, nourished white male, who was ambulatory. There was a mild icteric tinge to the sclerae and conjunctivae. A moderate degree of pitting scars were found on his face, back and neck due to acne vulgaris. Blood pressure was 114/76. The head, neck, chest and heart borders were normal. There were no thrills, murmurs or arrhythmia. On inspection a distinct bulging was noted in the left upper quadrant. The spleen was very definitely enlarged so that the lower border of the spleen was felt

at a level of about four fingerbreadths below the costal margin and was at the level of the umbilicus. The liver and kidneys were not made out. There were no other masses demonstrable in the abdomen and no tenderness or rigidity. The genitourinary, musculoskeletal and neuropsychiatric systems were essentially normal.

Preoperatively, on March 9, 1945, the red blood count was 3,900,000; white blood count 5,900; hemoglobin 77 per cent, platelets 312,000; differential—polymorphonuclears 46 (4 staffs); lymphocytes 46; monocytes 2; eosinophiles 1; reticulocytes 1.2 per cent. On March 15, 1945, the red blood count was 4,190,000; white blood count 1,207; differential—polymorphonuclears 76 (3 staffs); lymphocytes 22; monocytes 2; eosinophiles 1; basophiles 1, hemoglobin 77 per cent, sedimentation rate 8. On March 17, 1945, the white blood count was 16,600; polymorphonuclears 78; lymphocytes 21; eosinophiles 3; basophiles 3; reticulocytes 11. (Just prior to the onset of this elevated white count, the patient had a mild upper respiratory infection with some pharyngitis.) There was some poikilocytosis and slight anisocytosis noted in the peripheral blood smear. (Throat smear taken at that time showed some *Staphylococci aureus*.) The white count taken on March 16, 1945, during the upper respiratory infection showed white blood count 10,007; differential relatively unchanged as of March 17, 1945. *Red blood cell fragility test*: March 19, 1945: Beginning hemolysis .44; complete hemolysis .38. This was preoperative erythrocyte fragility determination. This was repeated on March 16, 1945, and beginning hemolysis was noted as .46 and hemolysis was complete at .36. The normal limits are .44 to .32. *Icteric index*: March 9, 1945: 25. *Van den Berg's test*: Delayed direct reaction. *Sternal marrow study*: March 17, 1945: Red blood count 4,070,000; nucleated cells 109,800; differential—polymorphonuclears 16.5 plus 17 immature staff cells; lymphocytes 10.8 eosinophiles 2.1; basophiles .1; normoblasts 29; megaloblasts .8; degenerates 3.1; neutrophilic myeloblasts 16.4; eosinophilic myeloblasts .5; hemoglobin 81 per cent. Peroxidase stain showed 79 per cent granular cells, 21 per cent non-granular cells. *Gastric analysis*: Ewald meal—amount obtained 22 cc.; total acid 48 degrees; free acid 25 degrees; combined acid 18 degrees; no blood present. *Urinalysis*: essentially normal. Specific

gravity 1028. There was no albumin or sugar. Examination of the urine for urobilinogen disclosed presence of urobilinogen in moderate amount (March 13, 1945). *Liver function test*: Ceph. flocculation—4 plus. Takata Ara—4 plus. Van Den Burgh—negative direct reaction. *Prothrombin time*: A preoperative prothrombin time was requested but due to technical difficulties was not completed. *Stools*: Negative for blood. *Determination of blood type and Rh factor*: Blood type was "O," and he was Rh positive. *Blood smears of the peripheral blood*: Counts of wet smears, showed an occasional (3 per cent) spherocyte; they were very distinctly in the minority, however. There was also a rare spherocyte in the bone marrow study. Studies for presence of hemolysins were not carried out.

Chest plates disclosed the chest to be normal. Diaphragms were smooth. The heart and lungs were within normal limits. Gallbladder visualization disclosed faint visualization of the biliary tract, although the concentration was quite low. The x-ray impression was that of a faintly visualized gallbladder but with evidence of a good emptying time, indicating a normal functioning gallbladder. Radiograms of the skull, dorsal vertebrae, hands and pelvis were taken to rule out the possibility of evidence of bone marrow hyperplasia and hypertrophy. There was no evidence of any abnormality of the bony architecture of any of the above structures.

Based on the above data we believed that we were dealing with a case of congenital hemolytic icterus despite some of the atypical findings. Accordingly, splenectomy was recommended and carried out on March 21, 1945. There were no unusual problems at time of surgery and the spleen was seen to be considerably enlarged, weighing 866 Gm. (Table 11.)

The specimen was submitted to Dr. Frank R. Menne, Pathologist, University of Oregon Medical School, whose report was as follows:

Gross: Specimen consists of spleen. It is markedly enlarged—weighing 866 Gm. It measures 22.0 by 13.0 by 9 cm. in size. The cut surface is deep reddish purple. The trabeculae are increased in amount. The follicles are uniformly enlarged. They are pinhead in size. Bloody fluid can be scraped from the pulp.

Microscopic Findings: The capsule of the spleen is intact. The pulp is filled with red blood cells to an incredible degree, so that the usual

markings are missed although an occasional follicle can be seen.

Pathological Diagnosis: Splenomegaly due to chronic hemolytic icterus.

COMMENTS

We believe that this case represents another instance of true familial hemolytic icterus with normal red cell fragility. In addition, the presence of very few microspherocytes in the peripheral blood (average 3 per cent) is indeed unusual. In the case reported by Hurley and Moore,¹⁶ the same observation is made. As a matter of fact, they state at no time during the period of observation were they able to observe any microspherocytes. They also observed a normal reticulocyte count. It seems then possible to infer that in our case, the normal fragility here may be related to the paucity of spherocytes which are responsible for its increased fragility. On the other hand, normal fragility has been explained by some on the (Cheney¹⁷ Reynolds¹⁸), basis that the reticulated red cells are more resistant to hemolysis than a normal red blood cell. This hypothesis has not found much support, but it could apply here in view of our findings of relatively high reticulocytosis.

Of additional interest is the unusual hemolytic crisis occurring postoperatively with a drop in blood count to about two and a half million, etc. This is not readily explained and is most unusual, postoperatively. On the other hand, preoperatively, crises have been brought about by blood transfusions and are generally known. This has been emphasized in the literature,^{19,20} and it is generally appreciated with preoperative blood transfusions. In congenital hemolytic anemia, it is contraindicated even if the anemia is striking. It may indeed be fatal at this time, viz., preoperatively.

On the other hand, transfusion after the splenic pedicle has been clamped is perfectly safe. It is not often necessary because of the so-called autotransfusion

reaction which occurs with splenectomy. It is because of this reaction that splenectomy may be fairly safely undertaken even in very anemic patients.

The phenomenon of the autotransfusion reaction immediately following splenectomy is generally known. Its value as a confirmatory diagnostic measure is acknowledged and generally appreciated in the literature. Similarly, absence of such reaction is highly suggestive of a probable poor result to follow. The phenomenon of autotransfusion has almost been universally observed in typical hemolytic anemia treated by splenectomy.

In the autotransfusion reaction the most significant response is the so-called reticulocyte response to splenectomy as manifested by a very prompt rise of the peripheral blood count. However, along with this reticulocyte response there is also noted a very distinct rise in the white and platelet count as a result of the autotransfusion. It is indeed striking to note that in our patient this reaction began to manifest itself. There was a very distinct rise in the platelet count, in the white count and in the erythrocytes. However, this was not sustained. While the platelet count and the white blood count continued elevated, in about twenty-four hours the red blood count dropped very abruptly. The patient's pulse became very poor, and he appeared to be in shock. There was no evidence of any acute bleeding, however. The reaction probably represents some unexplained type of hemolytic crises, the exact basis of which is not clear at this time. He was given several transfusions, and his red blood count began to rise immediately. His white count and platelet count continued high. In the few days following splenectomy, it was observed that his reticulocyte count began to drop and approach normal and similarly, his icterus began to subside, and within a short time his icteric index was relatively normal.

The indications, advisability and poor results of splenectomy are indeed impor-

tant to bear in mind. True cases of congenital hemolytic anemia give rather uniformly good results. The cases of so-called atypical or acquired congenital hemolytic anemia give uniformly poor results. Thompson finds such poor results in fifteen cases²¹

chronic variety are poor risks. After a period of many years, they make a relative adjustment to their disease. In any event, they may be benefited by liver extract and can be carried along quite comfortably. The mother of our patient

TABLE II
TABLE OF PRE- AND POSTOPERATIVE LABORATORY DATA

Date	RBC in Millions	WBC	Platelet Count	Reticulocytes, Per Cent	Hemoglobin, Per Cent	Remarks and Other Data
Pre-op	3.91	5,900	.....	12	77	Takata Ara 4+
3/9/45						Van Den Berg neg.
3/17/45	....	16,600	.....	11.7	..	Ceph. Chol. Flocc 4+
						Sed. Rate 8
3/20/45	3.8	8,400	.....	12	76	RBC Fragility
						Begins .44, ends .38
Operation	3.47	10,500	309,000	14.3	81	Icterus 25
3/21/45						Urobilog. urine +
3/21/45	3.1	11,600	311,000	14.5	81	RBC Fragility
25 min. p.o.						Begins .46, ends .36
3/21/45	3.2	9,400	315,000	15.2	81	
25 min. p.o.						
3/21/45	3.1	17,200	331,000	15.1	69	
2 hrs. p.o.						
3/21/45	4.7	26,300	190,000	14.5	78	
5 hrs. p.o.						
3/22/45	3.3	39,000	376,000	14.5	57	
24 hrs. p.o.						
3/22/45	3.25	28,500	.....	....	55	
36 hrs. p.o.						
3/23/45	2.37	31,000	298,000	15.5	..	RBC Fragility
48 hrs. p.o.						Begins .46, ends .32
3/24/45	2.48	15,400	.....	....	47	
3/25/45	3.5	16,000	.....	....	62	
3/26/45	3.05	18,500	.....	....	61	Icterus 30
3/29/45	3.89	16,500	.....	....	78	
3/31/45	4.88	21,200	.....	....	88	
4/2/45	4.2	11,100	.....	1.7	84	Ceph. Chol. Flocc 2+
4/3/45	4.12	14,100	.....	....	83	Icterus 20
4/5/45	4.5	14,200	76,000?	....	80	
4/7/45	4.1	.....	.....	....	80	
4/9/45	4.1	13,400	.....	....	80	
4/12/45	....	.....	.....	0.8	..	Icterus 7
4/13/45	3.9	8,200	210,000	0.5	78	RBC Fragility
						Begins .42, ends .36
5/2/45	4.3	12,200	120,000	..	81	Icterus 9
						Ceph. Chol. Flocc. neg.
5/31/45	4.5	15,500	288,000	1.0	81	Icterus 7

out of forty-five reported cases. Freund²² has reported poor results from splenectomy in children, one with probable congenital and the other, acquired hemolytic jaundice. Ordinarily, the best results have been obtained in younger people. On the other hand, older people with a more

falls in this category and is presently being treated with liver extract. Although her peripheral blood count is down she feels fair. The advisability of splenectomy has been considered in her case and has been rejected at this time because of the above factors.

While splenectomy ordinarily effects a very striking and dramatic cure in most cases of true so-called congenital hemolytic icterus, failures have been recorded. Several reasons have been advanced. First, some hemolymph tissue or accessory spleen may have been overlooked at the time of surgery. The importance of an accessory spleen has been emphasized by Curtis and White²³ who report its presence in 10 per cent of autopsy material studied and in 20 per cent of their cases in congenital hemolytic jaundice coming to operation. In each patient they report the accessory spleen was found in or took its attachment from the principle pedicle of the spleen. Second, another possible explanation for failure of splenectomy is the presence of so-called hemolymph tissue. Hemolymph structures, such as the abdominal hemolymph nodes, undergo striking hypertrophy and assume hemolytic characteristics. An example of this is the case reported by McLaughlin.²⁴ Third, one must remember that there may be a wrong diagnosis and that one may not be dealing with a true congenital hemolytic icterus, but rather with an acquired variety which does not ordinarily respond to splenectomy. Fourth, the possibility of hemolysins playing a rôle and producing continued hemolytic effect should also be borne in mind.

An interesting observation here is the presence of unexplained liver damage which rapidly improved following splenectomy. (Table 11.)

One last feature of significance of congenital hemolytic icterus is the presence of gallbladder disease in about 70 per cent of the patients. This is due to the formation of stones which are formed by the broken down hemoglobin due to episodes of deglobulinization, producing excess bilirubin and bile pigment. Many patients will enter with their primary complaints centered around and referable to the gallbladder. Our patient had no complaint referable to the gallbladder, and at time of laparotomy, examination of the gallbladder revealed it to be essentially normal.

SUMMARY

1. Study of a case of congenital hemolytic icterus cured by splenectomy with the following unusual features is reported: (1) Normal red blood cell fragility; (2) minimal microspherulosis; (3) the presence of liver damage improved by splenectomy; and (4) the occurrence of an unusual post-operative hemolytic crisis.

2. The hypotheses on etiology are reviewed.

3. The effects of splenectomy and the reasons for failure in certain instances are considered.

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INTERSTITIAL HERNIA

REVIEW OF THE LITERATURE AND REPORT OF THREE CASES

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IN the nomenclature of ventral abdominal hernia, a great deal of confusion exists. It will clarify our present discussion if at the onset, we define interstitial hernia. It is a form of an indirect (oblique) inguinal hernia which emerges from the abdomen through the internal abdominal ring but does not descend through the inguinal canal. Instead the sac spreads out between the layers of the anterior abdominal wall.

The hernia sac may be located between any of the layers of the abdominal wall but most commonly it is found between the internal oblique and the aponeurosis of the external oblique. Lower and Hicken¹ call these hernias "interparietal" instead of "interstitial." Based upon the location of the sac they classify the varieties as follows: (1) Properitoneal hernia in which the sac lies anterior to the peritoneum but deep to the transversalis fascia, (2) interstitial hernia in which the sac is located between the transversalis fascia but beneath the external oblique, and (3) superficial hernia in which the sac is superficial to the external oblique. From an anatomic basis, this classification is splendid but the commonly accepted term is "interstitial hernia."

In these hernias, the direction taken by the sac is also variable. The sac may pass upward well above its point of emergence from the abdomen; it may extend laterally in the direction of the location of the anterior superior iliac spine; it may be displaced medially in a variable relationship to the rectus muscle. The location of the sac will obviously depend upon the site of the congenital or acquired weakness of one of more structures that go to make up

the abdominal wall. Very frequently the sac is bilobed and occasionally there are three lobes. Commonly the most proximal of these sacs is located at the level of the peritoneum while the other and usually the larger one extends out between the layers of the abdominal wall. Here we should note the similarity to the two-legged sac so frequently encountered in the common type of indirect inguinal hernia, in which the second sac is of the direct type and is often missed at operation resulting in so-called recurrence.

The contents of the sac vary. Omentum is a frequent occupant. Small or large bowel are also commonly found. Sometimes the hernia is of the sliding type. Often the bladder may occupy the sac either as a partial prolapse or as an actual diverticulum. The sac may contain nothing but fluid. Holmes² reports a case of properitoneal hydrocele which was trilobular, two of the sacs being located in the scrotum and the third within the abdomen. It is most uncommon for other viscera such as the pelvic organs to migrate into the sac.

Interstitial hernias are more common in males and are quite frequently associated with some form of mal-descent of the testicle which emphasizes the importance of the congenital factor again. However, there are reported a fair number of such hernias in females.

The symptoms of interstitial hernia are often very confusing. Frequently the diagnosis is not made until the patient comes to surgery; occasionally it is missed even at operation and only determined at autopsy. Obviously the size of the hernia sac, its contents, the presence or absence of strangulation, etc., are factors which alter

the symptoms. Many patients complain only of pain or discomfort in the lower abdomen. This is usually relieved when the patient goes to bed and gradually increases as he is up and about. They may describe it as a dragging sensation that they are not able to localize accurately. Usually the physical examination is not particularly revealing especially if the person has a thick abdominal wall. This type of individual often goes from one physician to another and the true diagnosis is not recognized until exploratory operation is done. Obviously if a thorough exploration of the abdomen is made, the hernia emerging through the anterior abdominal wall should be recognized. Many operators, however, explore only within the abdomen and overlook the anterior abdominal wall. It is always wise, when the abdomen is opened for any cause other than peritonitis, to explore the internal openings of inguinal and femoral regions digitally. Also, the relative thickness of the abdominal wall on both sides of the incision should be compared. In one of the cases reported below, the diagnosis was made at operation by noting increased thickening of the abdominal wall on one side of the incision.

Other patients consult the surgeon because of a mass in the lower abdomen. Often they have discovered it themselves and desire advice. These persons may tell you that the mass seems to get smaller when they go to bed and larger when they are up. Upon examining these individuals the mass may be easily felt at times although in some cases it seems to disappear during examination and thus leaves an element of uncertainty in the mind of the examiner. The mass will vary in size and consistency and its location is often indefinite. Different examiners may be inclined to believe that the mass occupies entirely different levels. In one of the cases reported below, the author was of the opinion that it was related to the kidney; his resident was sure that it was ovarian in origin. References to similar confusion abound in the cases reported in

the literature. Some patients were studied for renal tumor and had complete urological work-ups. In a case reported by Gray and Horwitz³ the mass was thought to be a large gallbladder. It was only when x-ray films were made of the intestinal tract and loops of gut were seen apparently outside of the abdominal wall, that the true diagnosis was realized. Finally, after having eliminated most of the common causes of abdominal tumor, we may be tempted to consider it as a true tumor of the abdominal wall such as a desmoid, a hematoma or abscess.

A fairly large group of these patients present quite typical symptoms of acute mechanical intestinal obstruction. The only preoperative diagnosis is that of obstruction with cause unknown. Obviously in the presence of advanced obstruction with large dilated coils of gut hampering exploration, the diagnosis may be overlooked and be determined only at the postmortem table.

If a portion of the bladder occupies the sac, the symptoms often point to the urinary tract and this is studied completely before surgery is resorted to. The picture may be further confused in patients who in addition to an interstitial hernia do have some lesion of the urinary tract. White⁴ reports a case of traumatic hernia of the bladder with an interstitial hernia.

Occasionally an interstitial hernia is associated with the usual type of hernia and is not discovered until repair of the inguinal hernia is undertaken. Beigler⁵ reports such an interesting finding.

From the above mentioned symptoms, it is obvious that the diagnosis of this condition may be very difficult. Repeated examinations in the decubitus and erect positions are helpful. Pelvic and rectal examinations may eliminate a tumor of the pelvic viscera. In some instances intravenous pyelograms or a complete urological study may be required. Perhaps x-ray studies of the intestinal tract may seem indicated. Naturally, such procedures are reserved for the patient who is not

acutely ill. In the obstructed group of patients, probably the only justified procedure is a flat plate of the abdomen which may be very informative.

As implied, the condition of interstitial hernia may be a serious one especially in the group of patients who present an acute obstruction. The difficulty of diagnosis and the seriousness of some of the complications combine to make this condition responsible for a rather high death rate.

The treatment is obviously operative. Often the initial incision is of the exploratory type in the lower mid-line. This does not lend itself to repair of a laterally located hernia; however, in some cases by retraction of the overlying layers, the hernia may be exposed and a satisfactory repair accomplished. More commonly, a better repair can be done if the primary incision is closed and the region of the hernia exposed through a conventional incision. If the hernia mass is reducible from within the abdomen, in a few cases a repair can be done from within entirely. Most of these hernias are difficult of repair and it seems wise to have adequate exposure. We have followed the modified Halsted procedure for we believe that it offers the best chance of permanent cure. If a bladder diverticulum is found in the sac, it may be wise to resect it in addition to repairing the hernia. Careful search should always be made for more than one sac in view of the common finding of a double sac.

CASE REPORTS

CASE 1. M. P., a female, age sixty-one, was first seen August 26, 1944. She was complaining of a swelling in the left lower quadrant with pains in that location on and off for some four or five years. During the past few months the pain had increased. There was no disturbance of bowel habit. There was a history of frequency and burning on urination for several weeks. The remainder of the history seemed irrelevant. Upon physical examination a soft tumor mass, the size of an orange, was felt in the lower left quadrant; it seemed to be fixed to the anterior abdominal wall; there was a

suggestion of an impulse on coughing. Pelvic examination was negative except for a relaxed pelvic floor. Because of the history of urinary tract disturbance, an intravenous pyelogram was done with essentially negative findings. The routine study of urine and blood were negative. A few days after admission to the hospital, the mass was explored through a left rectus incision. A single hernia sac about the size of a small orange was found anterior to the aponeurosis of the external oblique through which it emerged at a site immediately over the internal abdominal ring. The sac contained adherent omentum. After incision of the sac the contents were reduced. The aponeurosis of the external oblique was then split upward and downward to secure the usual exposure of the floor of the inguinal canal. The sac was dissected well and was transfixed and ligated at its neck. A Halsted type of repair was then done utilizing black silk throughout. The patient made an uneventful postoperative recovery and recent check-up reveals no apparent weakness at the site.

CASE 11. A female, age sixty-four, was first seen on March 7, 1944, at which time she was complaining of pains in her lower abdomen which had existed for about seven months. At times the patient thought there was a "bunch" in right lower part of the abdomen. During this period, there had been a tendency toward constipation and the patient had found it necessary to resort to cathartics which was unusual. Also there had been a loss of ten pounds during this period. In addition there was some frequency of urination. Examination of this patient revealed a slightly tender, moderately movable mass in the right lower quadrant. No impulse on coughing was detected. Blood examination showed a moderate secondary anemia and a sedimentation rate of 16 (Wintrobe). The impression at this time was that the condition was probably a tumor of the cecum. Accordingly, a barium enema study was done with no significant findings. Four days after admission the mass was explored through a right paramedian incision. As the aponeurosis of the external oblique was exposed, a bulging was noted in the region of the inguinal canal. The skin incision was carried lateral so that by retraction the inguinal area was uncovered. The aponeurosis of the external oblique was then split upward from the external ring along the line of the inguinal

canal. This revealed a hernia sac, the size of a hen's egg, which emerged through the internal ring and spread medially and upward to the plane between the posterior rectus sheath and the rectus muscle. The sac contained omentum which was easily reduced after incision. The sac was dissected out and after search for another lobe, the sac was ligated high up, the distal portion being removed. The canal was then closed by the Halsted method using black silk. The patient made a satisfactory post-operative recovery. Recent examination reveals no recurrence.

CASE III. C. M., a female, age sixty-eight, was first seen October 10, 1945. She was complaining of a "bunch" in the left upper quadrant for three years. It had gradually increased in size and lately caused some pain. The patient stated that the mass seemed to move; sometimes it appeared to be just underneath the ribs and at other times it was below the level of the navel. Associated with this complaint was the story of considerable gas and increasing constipation. Physical examination revealed a rather firm mass, about the size of a grapefruit in the left half of the abdomen at the level of the umbilicus. The mass was moderately fixed and no impulse on coughing was detected. Pelvic examination was not satisfactory but the mass could not be felt. A scout plate of the abdomen was negative. It was believed that the mass was probably an ovarian tumor. Exploration through a mid-line suprapubic incision was carried out. Upon entering the abdominal cavity, much to our amazement, we found no tumor. Examination of the left side of the abdominal wall revealed marked thickening and palpation of the region of the internal abdominal ring disclosed a hernia mass entering

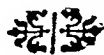
it. The abdominal incision was enlarged and retracted to expose the left inguinal region. The usual exposure through the external oblique was done. A large sized, single hernia sac containing a sliding hernia of the sigmoid was found. The sac had spread out between the two obliques, above and lateral to the internal ring. The sac was trimmed as close to the sigmoid as possible and then closed with a running suture. The inguinal canal was repaired with black silk after the Halsted technic. This patient has recently been examined and at present, no recurrence seems to exist.

CONCLUSIONS

1. The literature on interstitial hernia has been reviewed and the problem discussed.
2. Three additional cases are reported.
3. The difficulty of diagnosis is stressed.
4. The importance of the finding at operation of an increased thickening of one side of the incision is noted.
5. The need for careful examination of the posterior surface of the anterior abdominal wall during exploratory operations is emphasized.

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INCIPIENT EPIPHYSEOLISTHESIS OF THE HIP*

ITS DIAGNOSIS AND TREATMENT

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ALL of us are confronted with cases of disabling arthritis of the hip joint in adults traceable to an epiphyseolisthesis in adolescence. There is a variable but persistent disability, pain and a limp which, appearing insidiously in the third or fourth decade, increase in intensity, disturb the function of the limb and interfere with the normal activities of the individual. On close questioning, one elicits the fact that the patient had for many years been aware of occasional stiffness of the hip and lack of complete freedom in locomotion, but was so accustomed to these conditions that he paid little attention to them. It is only when the locomotor discomfort and disability become marked that the individual is compelled to take note of them. The symptoms are the result of a permanent structural damage to the head of the femur characterized by an enlargement and deformity of the femoral head, irregularity of its articular contour and surface and, not infrequently, a partial luxation. The disability may become severe enough to require major surgery such as a transpositional osteotomy, an arthroplasty or an arthrodesis to ameliorate the symptoms. In no such instance can a normally functioning hip and limb be obtained.

When one contemplates this situation one realizes that the dysfunction of the hip and its attendant symptoms are the result of inadequate treatment during adolescence. If we could prevent the slipping and the consequent deformation of the femoral head during the early phase of the ailment, an arthritis of the hip, otherwise an inevitable sequel of weight bearing, might not ensue at a later date. I am

under the strong impression, based so far on an experience with only a comparatively small although representative group of cases, that, if epiphysolisthesis is recognized in its incipency and the epiphyseal plate surgically obliterated, the head and neck of the femur would fuse, displacement and deformity of the head would be prevented, a normal blood supply to the head would be maintained through the cervical vessels, an arthritis from disturbed mechanics in the hip would be prevented and normal or practically normal function would be retained in the hip and limb.

The first step in the therapeutics of epiphyseolisthesis, and manifestly the most important one, is the recognition of this lesion in its incipency. A practical classification of the different stages or types of epiphyseolisthesis, based on the gross pathology and the therapeutic possibilities, is the following: (1) Incipient stage, (2) stage of moderate slipping, (3) stage of severe slipping, and (4) acute slipping.

Each of these types requires a different method of treatment, a treatment designed to correct or to improve a specific pathological condition. The results in types 1 and 4 can be a normal or *nearly* normal hip joint; the final outcome in the management of types 2 and 3 is always uncertain and never a normal hip.

Etiology. I shall omit any extensive comments on the etiology of epiphyseolisthesis because, in a word, no one has as yet been able to identify and establish unequivocally the exact cause or causes. There has been speculation about the influence of an endocrine disturbance, particularly in youths of the Fröhlich

* Read before the Orthopedic Section of the New York Academy of Medicine, March 15, 1946.

type with overgrowth of the adipose tissue and underdevelopment of the sex glands. This condition, if of importance in some cases, is manifestly not a factor in many others who give the appearance of normal anatomical and physiological development. A disturbed circulation in the femoral head and neck has been assumed to be the underlying basis in other cases, but no definite or consistent pathological state has been found to permit a logical explanation on this score. From time to time other causes have been proposed, but none have been substantiated or stood the test of time.

In the present study I shall confine myself to a consideration of only mild or incipient epiphyseolsthesis. It is my conviction that if at this stage of the malady treatment is applied which will eliminate the epiphyseal plate and cause the femoral head and neck to fuse, the pathological process will be arrested and a normal or nearly normal hip joint will be assured. It is of paramount importance, however, that the lesion be recognized before much slipping has occurred, because after substantial slipping has taken place, the results, except in the comparatively uncommon instances of acute slipping (group 4 in my classification), are anatomically and functionally uniformly poor.

Pathology. The morphological changes are best visualized in roentgenograms of the hip including anteroposterior and lateral views. The capital epiphysis or head has slipped downward, backward and inward on the neck but remains intimately attached to it. Normally, the head projects a little beyond the superior border of the neck forming a sort of "shoulder." This projection is reduced or obliterated. Depending on the degree of backward slipping the head may appear only slightly reduced in its vertical diameter or may be crescentic in shape instead of hemispherical. In the lateral view one may more readily see the downward displacement through projection of the head beyond the neck. The texture of the head is unaltered



FIG. 1. Note absence of "shoulder" at upper border of head and neck. There is widening and irregularity of epiphyseal plate and juxta-epiphyseal rarefaction and sclerosis in neck.

and the articular surface is smooth and unbroken.

The epiphyseal plate is thickened and irregular. Instead of being $\frac{1}{16}$ to $\frac{1}{8}$ of an inch in its vertical diameter, it may be $\frac{1}{4}$ of an inch thick and irregular in consistency.

The neck appears shortened and widened because of a relative anteversion. Directly beneath the epiphyseal plate there are usually several areas of rarefaction and sometimes some streaks of sclerosis are present. Elsewhere the neck has a uniform texture.

The head and neck are always in intimate contact but their relationship has been altered. All of the above mentioned changes are not always present or at least evident. They may all be seen in an anteroposterior view, or some may be visible in an anteroposterior film and others in the lateral roentgenogram. It is therefore imperative that the hip be viewed in different planes. (Figs. 1, 2 and 3.)

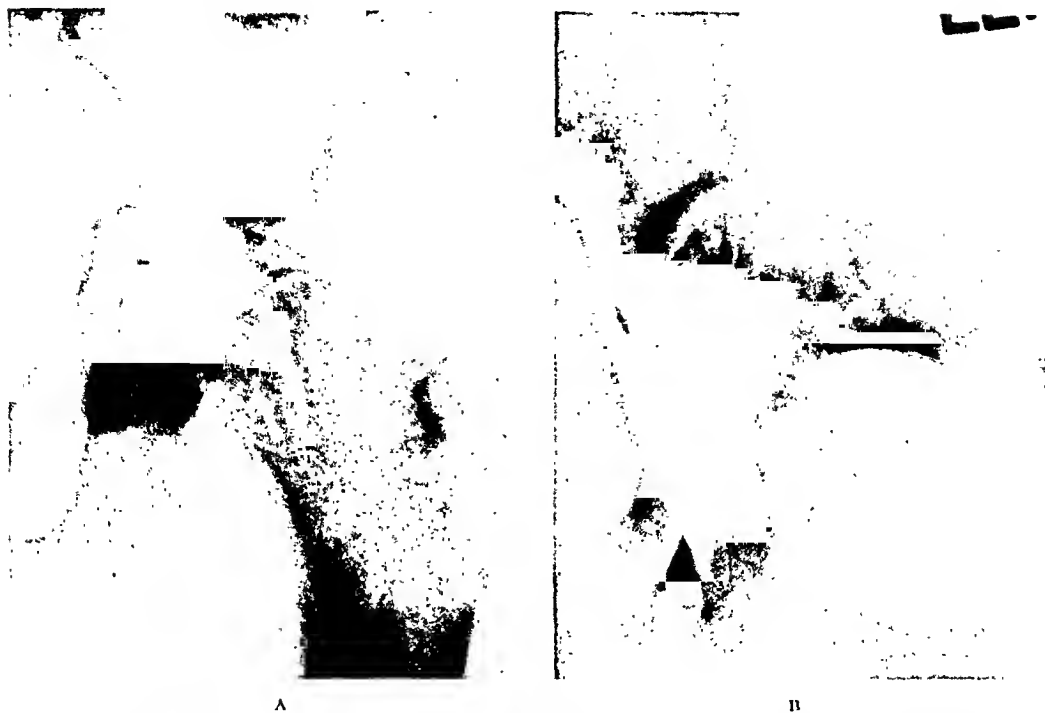


FIG. 2. A, loss of shoulder. The head is crescentic with widening of the neck and irregularity of the epiphyseal plate. B, lateral view of same hip. Slipping is evident and the epiphyseal plate is irregular.

Epiphyseolsthesis of the hip indicates a slipping of the head of the femur on the neck of the femur exactly as a spondylosthesis denotes a slipping of one vertebra on another. The basic lesion is in the epiphyseal plate. There is a metabolic and structural derangement in it which results in a weakening of the bond between the head and neck. The actual slipping is probably initiated by multiple minor traumas incidental to weight bearing enhanced in some cases by overweight. Once the slipping has begun it is likely to progress gradually or it may increase suddenly until the head is markedly displaced and the proximal surface of the neck is in contact with the anterior and upper portion of the acetabulum. In an undetermined percentage the slipping may remain mild even without treatment. The lesion being entirely within the capsule of the hip joint there ensues a congestion and ultimately an hypertrophy of the synovia as an expression of the irritation of the joint and nature's attempt at repair. The reparative process leads in the more

advanced cases to the formation of a pannus of synovia and to new bone deposit at the inferior junction of the head and neck, in an effort to arrest the slipping.

Symptomatology. From the above described pathology one can readily surmise the clinical course and the symptoms. A boy or girl, usually ten to thirteen years of age, after some minor injury, or just as often without any apparent trauma, experiences mild pain in the hip, thigh or knee and begins to limp. The limp may precede the pain. Neither symptom is severe at first and is rapidly relieved by rest. Both symptoms, intermittent at first, become more pronounced and persistent. The objective evidence of hip joint irritation is unequivocal. The patient walks with a limp. The affected limb is held in an attitude of outward rotation. Extension and outward rotation at the hip are usually free. Only exceptionally is there a slight flexion contraction. Flexion may be entirely free or moderately limited. Most frequently as the limb is flexed it goes into outward rotation. Inward rota-

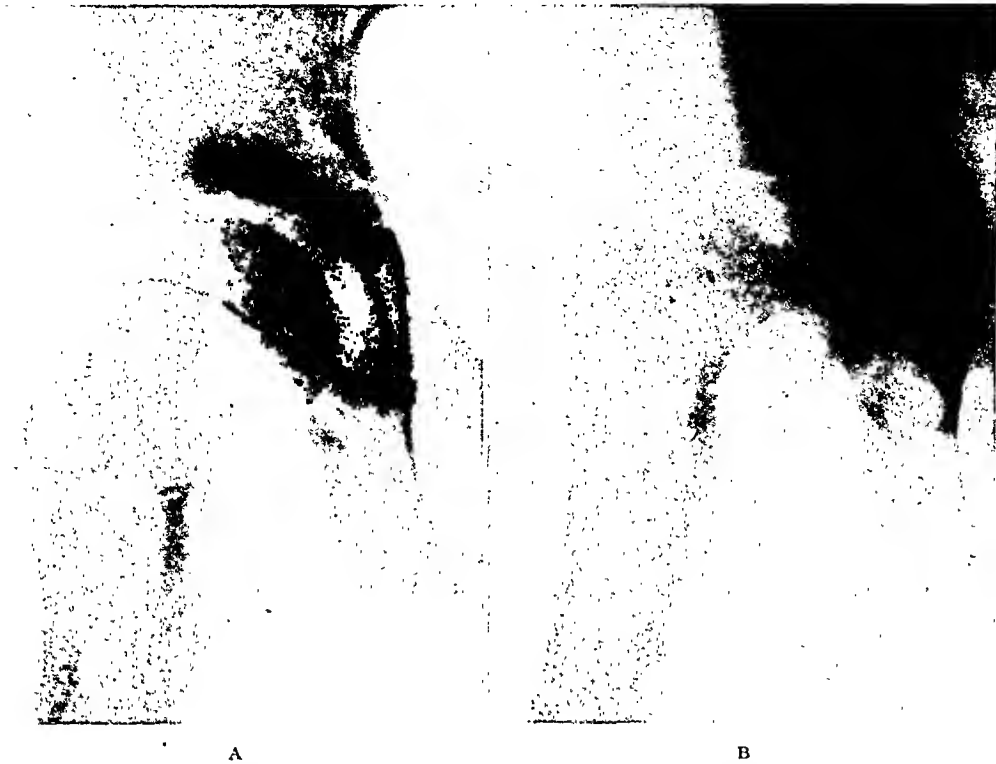


FIG. 3. A, film made June 2, 1941. There is marked widening of the epiphyseal plate and shortening of the neck. B, film made on June 3, 1941, when symptoms became acute. Note the marked displacement of head.

tion is very definitely and always restricted. It may be only mildly restricted or may be completely limited. In the very mildest cases the restriction of inward rotation is best appreciated by placing the patient in the prone position with the knees flexed and rolling his legs outward. Abduction is moderately restricted. There may be some sensitiveness to pressure over the front or lateral aspects of the hip. If the lesion has been present for several months, there will be an atrophy of the thigh of $\frac{1}{2}$ to 1 inch. The outstanding clinical features of the affected limb are an attitude of outward rotation and limitation of the movement of inward rotation. The history in an adolescent child of an intermittent limp and the finding of the limb in resistant outward rotation are as characteristic of epiphyseolsthesis as the history of sudden disability in an elderly individual coupled with a painful limb in outward rotation are significant of a fracture of the neck of the femur.

As was previously stated recognition of epiphyseolsthesis in its incipient stage is indispensable for the application of effec-

tive treatment. Fortunately, the objective signs, both clinical and roentgenographic, seen in a youth ten to fifteen years of age, particularly in an overgrown fat boy, leave no room for doubt about the diagnosis.

When the diagnosis of incipient epiphyseolsthesis has been established treatment should be instituted promptly. There is, to be sure, no such emergency as in the management of an acute appendicitis. But one must not feel that weeks and months can be allowed to slip by for the following reasons: (1) The slipping of the femoral head may increase at any time, without any appreciable provocation, so that the epiphyseolsthesis enters into the second stage or stage of moderate slipping when the opportunity for an optimum result is lost. (2) An injury, such as a fall or even a misstep will very likely increase the degree of slipping. (3) So long as the patient is walking and bearing weight on the affected limb not only may the slipping increase but, because of the altered mechanics, the hip is in a constant state of irritation. (4) Continuous irritation of the hip leads to congestion and hypertrophy

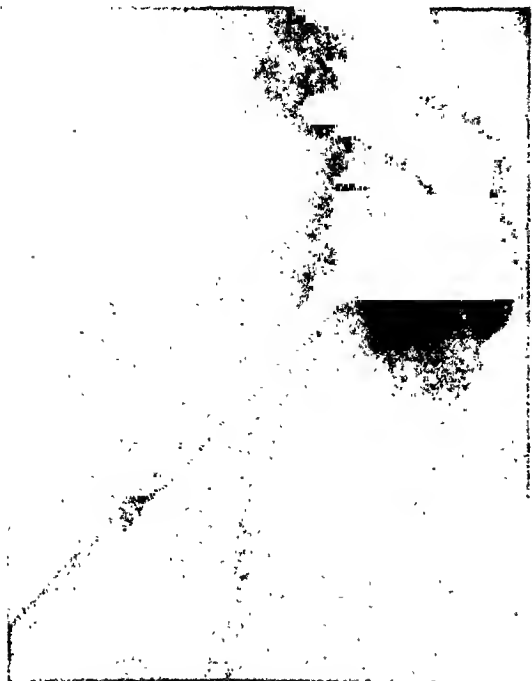


FIG. 4. This shows an ordinary drill inserted into the femoral neck and perforating the epiphyseal plate.

of the synovia and to the formation of a pannus of synovia over the margins of the articular cartilage, and consequent intra-articular adhesions and even new bone formation especially at the junction of the lower border of the head with the neck.

While we do not understand the etiological factors in epiphyseolsthesis, we do know that elimination of the epiphyseal plate and the resultant bony fusion of the femoral head and neck not only terminate the whole pathological process but establish a resistance in the hip adequate to meet the normal requirements of motion and weight bearing. The aim of treatment, therefore, is to eliminate the epiphyseal plate at the earliest possible moment when the head and neck are in normal or nearly normal relations. This can be accomplished through any one of several methods such as, drilling, nailing, pegging and hammering for impaction of the head and neck. My choice is drilling because it is the least traumatic and is positive in its effect. Perforation of the epiphyseal plate results in rapid vascularization and absorption of the cartilage and fusion of the femoral head

and neck. I shall, therefore, describe only this method of curing an incipient epiphyseolsthesis, and follow this by a recital of some case reports. Incidentally the loss of growth of the length of the femur from the induced absorption of the epiphyseal plate is so slight that it is, for practical purposes, entirely negligible. It goes without saying that drilling of the head and neck of the femur is not a new procedure. It has been used by many for a variety of lesions in the hip. I here only emphasize its particular value in epiphyseolsthesis.

Technic for Drilling of Hip in Incipient Epiphyseolsthesis. The operation is performed preferably under general anesthesia, and always with x-ray control. One requires several drills each 5 inches long and $\frac{3}{16}$ to $\frac{1}{16}$ of an inch in diameter. A 5-inch incision is made over the lateral aspect of the thigh beginning at the tip of the greater trochanter and extending downward. The first drill hole is made just below the trochanter. The drill is directed toward the middle of the femoral head the position of which is approximately half way between the anterior superior iliac spine and the symphysis pubis. It is estimated that in the average child of twelve to fifteen years of age the distance between the outer surface of the femur and the center of the head is about $3\frac{3}{4}$ inches. The drill is, therefore, inserted $3\frac{1}{2}$ inches and an x-ray film is made. (Fig. 4.) This will show both the position and direction of the drill. Since we wish only to penetrate the epiphyseal plate to establish a communicating tunnel between the neck and the head, the drill need enter the head for only a short distance, say $\frac{1}{4}$ inch beyond the epiphyseal plate. If the drill has been correctly and adequately inserted, one perforation has been made in the epiphyseal plate. Another should be made to facilitate and hasten vascularization, calcification and ossification of the epiphyseal plate. A second drill is, therefore, inserted just above or below the first one depending on its position. The drills are then withdrawn, the wound closed in layers and a long plaster of Paris spica

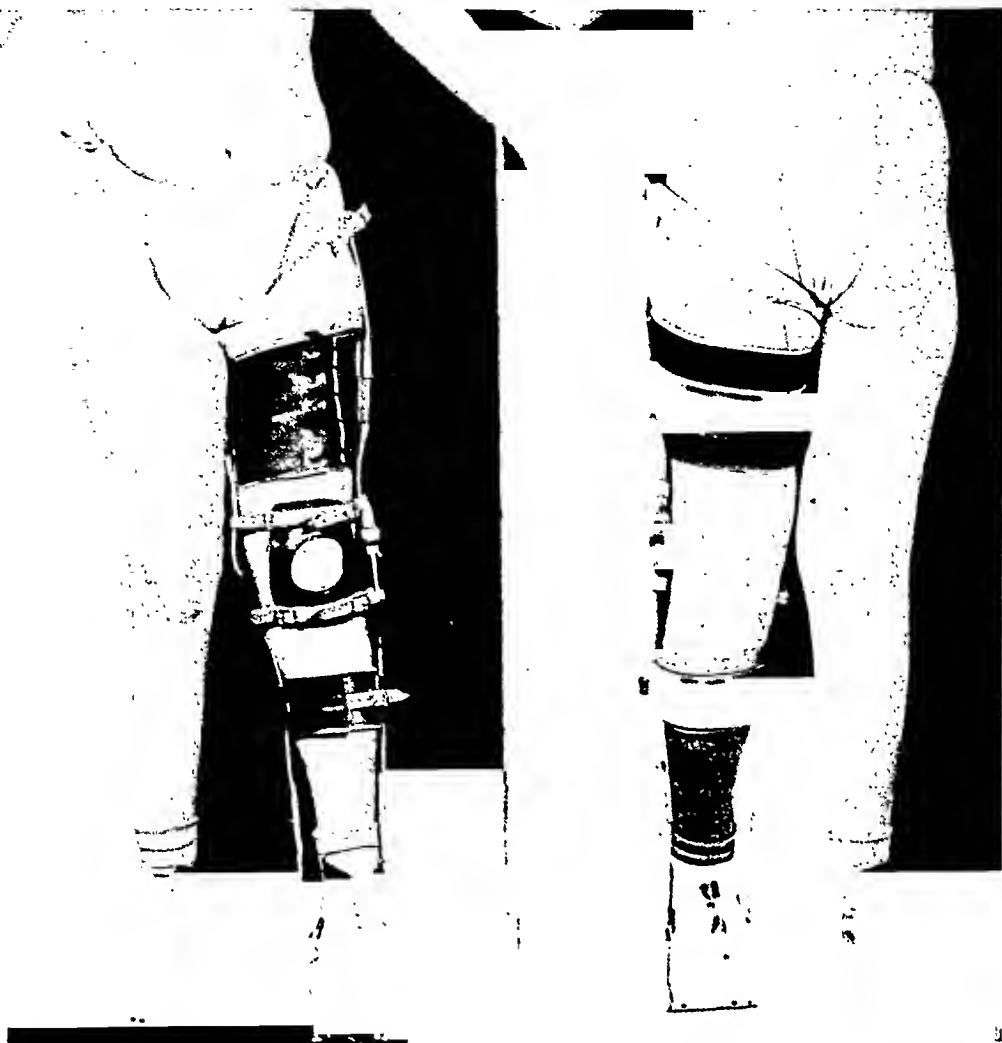


FIG. 5. Photo of a patient with a Thomas knee brace and ischial ring and a high shoe on the opposite foot to assure freedom from weight bearing on the affected hip.

dressings is applied for immobilization of the hip during the healing.

Postoperative Care. The plaster spica is left on for three months during which time the patient is kept in bed and not permitted to bear weight on the operated hip. He is then returned to the hospital, the plaster spica is removed and a new x-ray film made of the hip. It will generally be found that the head and neck are in good relation to each other. The epiphyseal plate is thinner than previously indicating a partial absorption. The drill channels are easily visualized. Another plaster of Paris spica is applied extending from the nipple line to at least the middle of the leg. Walking with crutches is now permitted but without weight bearing on the operated limb. Three months later another x-ray film is made. This usually shows that the

epiphyseal plate is now little more than a line and that the areas of juxta-epiphyseal sclerosis and porosis are becoming nearly normal in texture. The patient is now provided with a brace for support of the hip. (Fig. 5.) One may use a Thomas knee brace with an ischial seat or an ordinary Thomas knee brace extending several inches beyond the foot and provided with traction straps on the shoe, and a high shoe on the opposite side. The brace is worn for six months or a year or longer until there is complete osseous fusion between the head and neck of the femur, and the internal architecture of the head and neck assumes adult characteristics with the bone lamellae extending uninterruptedly from the neck into the head. During this period the hip and knee are mobilized through the use of physical therapy especially voluntary exercise in a

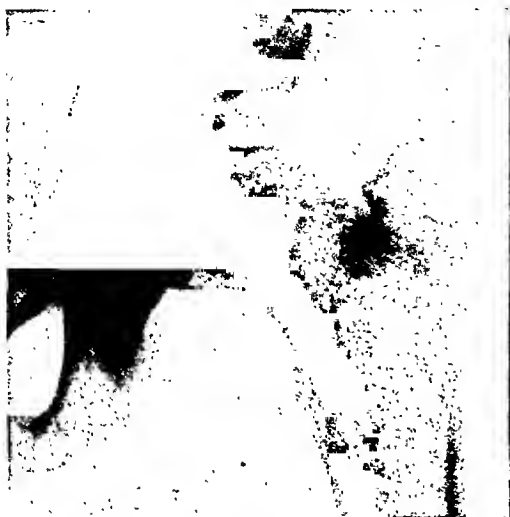


FIG. 6. Case I. K. K. September 26, 1934, shows slipping of the femoral head. The "shoulder" at junction of head and upper border of neck is gone. Epiphyseal plate is irregular and enlarged. The neck is shortened and broadened and has juxtaepiphyseal rarefactions.



FIG. 7. Case I. K. K. November 6, 1935, shows fusion of the head and neck. Epiphyseal plate has disappeared. The articular surface of the head is smooth. Conformation of the head is unchanged.



A



B

FIG. 8. Case II. H. B. July 20, 1944. A, anteroposterior view shows only slight reduction of "shoulder." B, lateral view shows irregularity of epiphyseal plate and definite slipping of the femoral head.

warm pool and passive movement of these joints.

ILLUSTRATIVE CASES

CASE I. K. K., a male, fourteen years old, was admitted to my service at the Hospital

for Joint Diseases on October 4, 1934, because of a limp on the left side. He was apparently well until one month previously when, without any known trauma and no preceding illness, he began to limp. He also had a mild pain in the left thigh which appeared only after he

walked a considerable distance and disappeared after a brief rest.

The physical examination showed that there was a persistent left limp. Abduction and inward rotation at the hip were mildly restricted. The x-ray films (Fig. 6) showed characteristic changes consisting of enlargement and irregularity of the epiphyseal plate, loss of the "shoulder" on the outer extremity of the head, juxta-epiphyseal rarefaction in the neck and shortening and widening of the neck. There was no doubt that he had an epiphyseolsthesis. Drilling was performed on October 5, 1934, and a plaster of Paris spica was applied. The spica was removed on January 18, 1935, the hip x-rayed and another spica applied. He was readmitted on April 22, 1935. At this time he had no pain but had some limitation of flexion and inward rotation. He was given a short spica and allowed to walk with crutches but without bearing weight on the operated limb.

Reëxamination in November, 1935, thirteen months after the drilling, showed a complete disappearance of the epiphyseal plate and fusion of the head and neck of the femur. (Fig. 7.)

A letter from the patient in 1945 reported that he was in the Army serving as a physiotherapist and that he had full function of the hip.

CASE II. Helene B., ten years old, came under my care in July, 1944. Her chief complaint was pain in the left knee and a limp. The symptoms began two months previously without any antecedent injury or illness.

The examination was negative except for the left hip. Flexion, extension, adduction and outward rotation of the hip were free but abduction was checked at an angle of 45 degrees and inward rotation was moderately but definitely limited. X-ray films (8A and B) showed a mild slipping of the capital epiphysis seen particularly well in the lateral view.

The hip was drilled on July 27, 1944. Three drill channels were made and a plaster spica was applied. On November 7, 1944, a new short plaster spica was applied and the patient was allowed to walk with crutches but without weight bearing on the operated limb. She was readmitted to the hospital on February 5, 1945. Clinical and x-ray examinations showed that there had been no further slipping and that the disappearance of the epiphyseal plate was progressing satisfactorily. She was provided



FIG. 9. Case II. H. B. September 4, 1945. Head and neck are fused. The epiphyseal plate is not visible and the size and shape of the head is normal.

with a Thomas knee brace with an ischial crutch and a high shoe on the opposite side. (Fig. 5.)

Reëxamination on September 4, 1945, fourteen months postoperatively, showed that the head and neck were completely fused and that the shape and size of the femoral head were normal. (Fig. 9.) Clinically, this patient had a full range of motion in the hip joint.

CASE III. Theodore K., fifteen years old, had bilateral epiphyseolsthesis. This boy was admitted to my service on October 19, 1942. His chief complaint was stiffness in his knees and a limp which began two months previously. There was no history of injury. The examination revealed a bilateral epiphyseolsthesis. On the right side (Fig. 10A and B) there was widening and irregularity of the epiphyseal plate and a reduction in the "shoulder" of the capital epiphysis. The lateral view showed a definite slipping. On the left side (11A and B) both the anteroposterior and the lateral films showed the characteristic evidences of slipping of the femoral head on the neck.

He had a drilling of both hips on October 28, 1942. He was given a bilateral plaster of Paris spica which was left on for three months.



FIG. 10. Case III. T. K. Right hip. A, October 19, 1942, anteroposterior view shows mild slipping and marked irregularity of the epiphyseal plate. B, October 19, 1942, lateral view shows definite slipping of femoral head. C, February 2, 1944, shows fusion of head and neck. Bone lamellae extend from neck into head; there is no evidence of epiphyseal plate.

Subsequently he had physical therapy but no weight bearing for many months.

Reëxamination on May 25, 1945, showed that he walked well and without a limp. There was a complete range of motion in the right hip. In the left hip he had slight limitation of

inward rotation but free motion in all other directions.

X-ray films made on February 1, 1944 (Figs. 10C and 11C) showed complete fusion of the femoral head and neck in each hip with no loss of substance or distortion of either head.



FIG. 11. Case III. T. K. Left hip. A, October 19, 1942, anteroposterior view shows undoubted beginning of slipping of femoral head; the "shoulder" is gone, the epiphyseal plate is irregular, and the upper border of neck is continuous with the articular surface of head. B, October 19, 1942, lateral view shows unquestionable slipping of femoral head. C, February 1, 1944, shows complete fusion of head and neck.

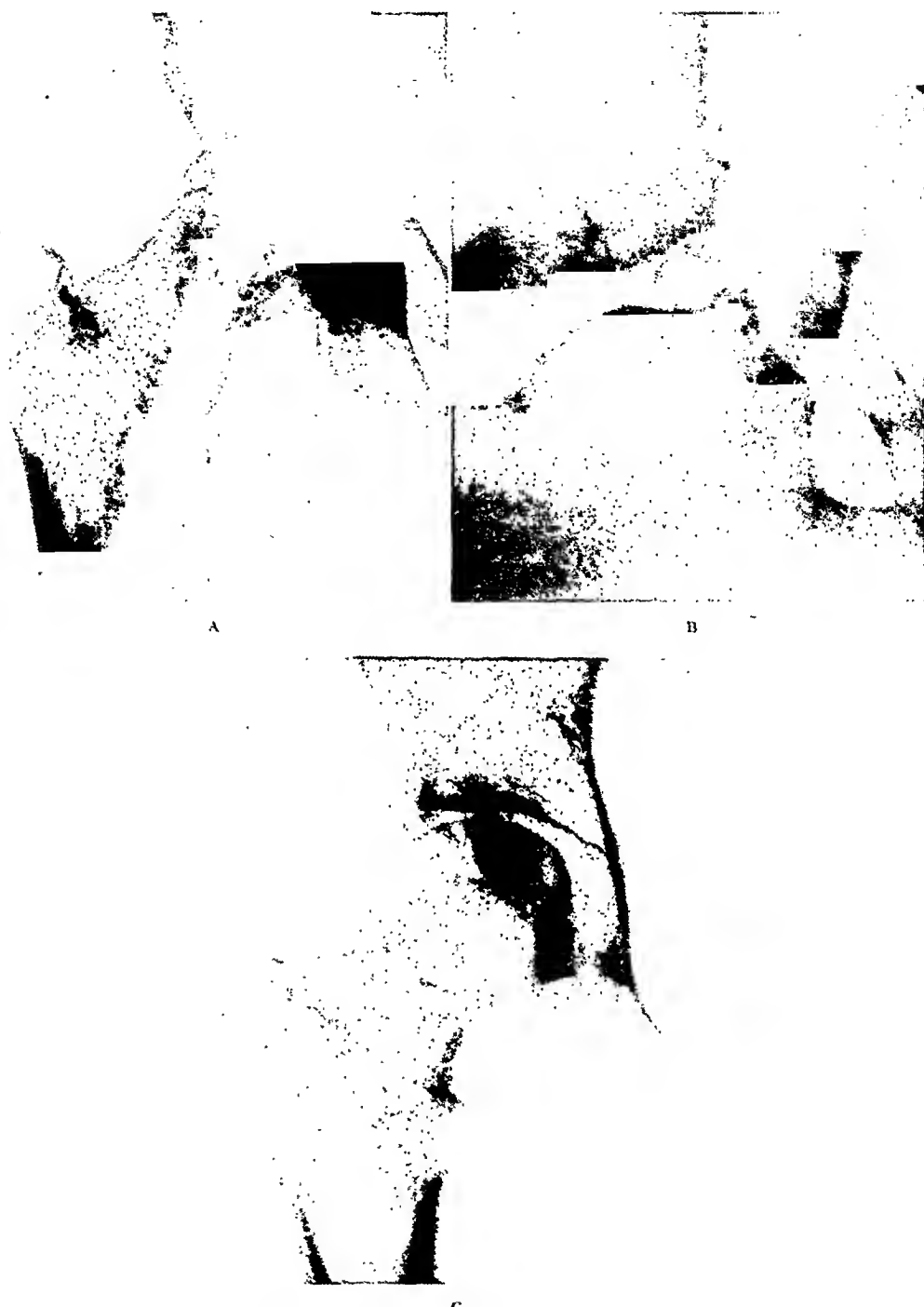


FIG. 12. Case IV. N. F. A, November 7, 1937, before drilling. Anteroposterior view shows that femoral head is crescentic. B, November 7, 1937, lateral view shows distinct slipping of the femoral head. C, September 27, 1945, eight years after operation. Head and neck are fused; the articular surface of the head is smooth.

CASE IV. Norma F., twelve and one-half years old, came under my care in November, 1937. Her chief complaint was pain in the right thigh and a limp. She began to favor the limb three months previously. The limp was present only at the beginning of walking but after a

few minutes she was able to walk freely and without a limp.

The examination showed that she walked with a limp. At the hip joint inward rotation was limited to 15 degrees. On flexing the thigh on the trunk the limb went into outward rota-

tion. Abduction was checked at 35 degrees. There was no tenderness to pressure over the hip and no shortening, but there was a $\frac{1}{2}$ inch atrophy of the thigh.

The x-ray films (Figs. 12A and B) showed in the anteroposterior view that the femoral head was slightly crescentic. The lateral film showed distinct slipping.

She was operated on November 30, 1937. Two drill channels were made. A plaster of Paris spica was applied. Three months later an x-ray film showed that the epiphyseal plate was disappearing. Weight bearing was not permitted until the head and neck became fused.

Reëxamination in September, 1945, eight years postoperatively, showed that the head and neck were fused. (Fig. 11C.) The articular surface of the head was smooth. Clinically, she was entirely well with a free range of motion in the hip in all directions.

The experience with the above illustrative cases, and about a dozen others, indicates that the elimination of the epiphyseal plate and fusion of the femoral head and neck can be easily accomplished through a simple drilling of the head and neck. The operation involves a minimum of trauma and does not subject the femoral head to the permanent housing of hardware

or to possible damage to its circulation through hammering. There has not elapsed enough time in any of our cases, including even the last one in which the period of observation has been eight years, to permit any dogmatic statements about the end results in adult life. But there is every reason to believe that since fusion of the head and neck occurs rapidly further slipping will not occur. In fact, in none of my cases has there been evidence of any further slipping beyond the slight degree present at the time of the drilling.

We may, I believe, further anticipate that since fusion of the head and neck is established during adolescence deformation of the head and arthritis will not develop during adult life. I, therefore, conclude that the most effective treatment for early adolescent slipping of the femoral head or epiphyseolisthesis, is drilling of the head and neck of the femur with freedom from weight bearing until, usually a matter of one to two years, the epiphyseal plate has disappeared, the head and neck have fused and bone lamellae extend uninterruptedly from the neck into the head.



CARCINOMA OF THE STOMACH*

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CARCINOMA of the stomach has always been a black chapter in surgery. Both diagnosis and therapy have been inadequate and relatively ineffective. Enormous achievement in other branches of abdominal surgery notwithstanding, the general outlook for a patient who has a malignant tumor arising in the stomach remains desperate and, in most cases, hopeless.

Cases of carcinoma of the stomach are seen initially by practitioners of every branch of medicine and surgery. Most of them, however, are still first seen by men in general medical practice. Even though an extreme effort has been made and much energy expended to educate the medical and lay worlds to the "look and see" rather than the "wait and see" policy for the management of chronic digestive complaints, surgeons even today see relatively few stomach tumors at an early stage. Of course, many more cases are being discovered now than ten years ago. Yet the stage of the disease, in most cases, is approximately the same as in cases diagnosed and treated previously. As a result, our splendid progress in bowel surgery technics were and are little more than futile surgical exercises.

These facts are neither pleasant nor novel. Today they remain as starkly defiant to surgeons and internists alike as they were many years ago. Large clinics may point with justifiable pride to a gradual increase in five-year survivals following gastrectomy, yet it has become increasingly evident that surgery, at its present level of diagnostic accuracy, is not the answer to carcinoma of the stomach as a disease entity.

Our purpose is to present carcinoma of

the stomach as it is seen in a modern 200-bed community hospital. Because our experience in treating these tumors has been grossly disappointing, certain quite natural mental reactions to the dilemma have repeatedly been noted. Why, for instance, does the general medical practitioner consistently send in cases after they are hopeless from the standpoint of surgical cure? Why are more cases not referred? Why are earlier roentgenological diagnoses not made? Have changes in surgical technic helped? Have laboratory diagnostic aids become more accurate? Is there any correlation between symptoms and types of tumors or their locations? The number and character of these questions which surgeons ask themselves are legion. Our own approach to the problem is simple. We shall, in this paper, attempt an analytical study of all of the cases of carcinoma of the stomach which were admitted and positively diagnosed, between the years 1917 and 1945. A total of 123 cases of "carcinoma of the stomach" were admitted. However, as is usually the situation, quite a number of the diagnoses are not proved beyond any question or doubt. Therefore, only the cases established by one or more of the following criteria will be studied here: (1) autopsy, (2) biopsy, and (3) operation. Even though the Beverly Hospital annually maintains a high necropsy and autopsy rate, we are able to present only sixty cases for detailed consideration. The cases have, in some instances, been divided into two sections for scrutiny and study regarding progress on changes in diagnosis, treatment and results. Thirty-one cases from the 1917 to 1937 period and twenty-nine cases since 1938 will be analyzed. (Table I.)

* From the Department of Surgery, Beverly Hospital, Beverly, Mass.

AGE INCIDENCE OF CARCINOMA OF THE STOMACH

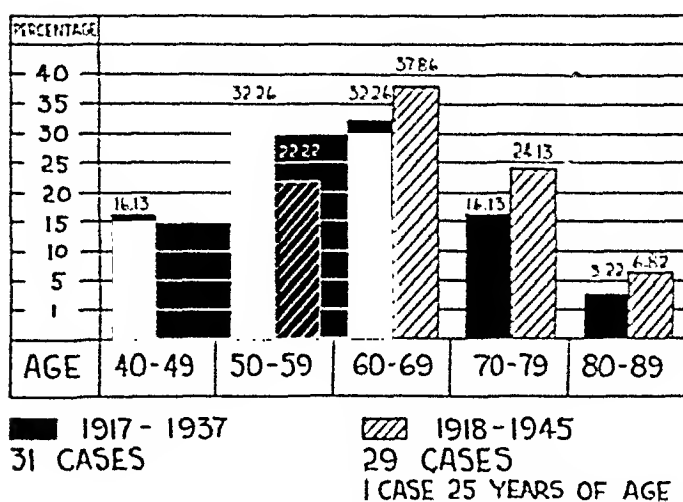


FIG. 1. Chart demonstrating age distribution; no essential change from the old to the newer group of cases.

No attempt will be made to review or summarize the tremendous fund of excellent articles on this subject to be found in medical literature. An attempt will be made to offer pointed suggestions for the ultimate solution of this problem which has rested heavily upon the conscience of those to whom has fallen the responsibility of treating neoplastic disease.

TABLE I

Total number of patients with Cancer of the Stomach from 1917 through 1937.....	70
Number of cases meeting one or more of criteria for analysis.....	31
Total number of patients with Cancer of the Stomach from 1937 to 1945.....	53
Number of cases meeting one or more of criteria..	29
Total cases 1917 to 1945	123
Total cases analyzed 1917 to 1945.....	60

Age. The average age of patients studied from 1917 to 1937 was 60.1, whereas the 1937 to 1945 series yielded an average of 58.6 years. (Table II.) This is an approximate agreement with the general opinion that carcinoma of the stomach occurs most frequently at the age of fifty-five. The youngest patient of the entire study was twenty-five, the oldest eighty-eight. Most of the carcinomas occurred during the fifth and sixth decades of life; there were none during the third. (Fig. 1.) The more recent series of cases gave practically no decrease in the average

age of our patients, even though a more intensive effort has been made to drive this disease into the open. This is not remarkable when one considers that: (1) Our diagnostic technics have changed but little; (2) symptoms occur late in the

TABLE II
AGE INCIDENCE OF CARCINOMA OF THE STOMACH

Age in Years	1917 to 1937 No. of Cases	1938 to 1945 No. of Cases
20-30	0	1
40-49	5	0
50-59	10	6
60-69	10	10
70-79	5	7
80-89	1	2
Average Age	60.1	58.6
Youngest	44	25
Oldest	88	86

development and spread of the tumor; and (3) the disease kills rapidly and is, therefore, probably not present as such to be diagnosed until a few months at most before the time at which it becomes inoperable or incurable.

Sex. The sex incidence of carcinoma of the stomach has long been known. The predominance of males has been accepted, though as shown in our series (Table III) and in studies by others, the ratio is not

1917-1937

SYMPTOMS	CASE NUMBER																															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
CHRONIC EPIGASTRIC PAIN OR ACHE																																
VOMITING																																
ACUTE ABDOMINAL PAIN																																
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FLATULENCE																																
ANOREXIA																																
JAUNDICE																																
ABDOMINAL TENDERNESS																																
DIARRHEA																																
MELENA																																
WEIGHT LOSS																																
GENERALIZED ASTHENIA																																
DYSPHAGIA																																
MASS IN ABDOMEN																																
FULNESS IN THROAT																																
CLAY STOOLS																																
HEMATEMESIS																																
VERTIGO																																
DISCOMFORT AFTER MEALS																																
FULNESS IN STOMACH																																
NAUSEA																																
CONSTIPATION																																
FLATUS																																
DARK URINE																																

FIG. 2. A, this chart reveals the typical varieties of syndromes to be found (in older group).

high enough to treat lightly a symptom complex which suggests the necessity for a full differential diagnosis in either sex. Mortality and morbidity as well as histopathology apparently do not differ by reason of sex alone.

Symptomatology. The symptom complex in this disease is fairly well defined and generally known. There is almost invariably a digestive complaint of some sort. In only 3.3 per cent of the cases there was no complaint even remotely referable to

the gastrointestinal tract. However, the single symptom which finally brought the patient to a physician varies considerably.

Chronic epigastric pain or ache was present as the specific chief complaint of 25 per cent of the patients. Another 18 per cent complained primarily of vomiting. Acute abdominal pain represented 8.3 per cent of the cases as the patient's most prominent symptom. The remainder of the patients revealed quite a varied assortment of primary discomforts and unusual

1938-1945

SYMPTOMS	CASE NUMBER																																																											
	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60																															
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B

FIG. 2. B, same as Fig. 2A except that these syndromes are from the newer group of cases.

happenings. (Table iv.) The combination of symptoms is frequently helpful, whereas the single most prominent symptom may not be at all. (Fig. 2 A and B.)

Duration of Symptoms. There were seventeen cases, or 28 per cent of the total number, in which symptoms of any sort did not develop until within one month of the time a physician was consulted. The average duration of symptoms before seeking medical care was 2.8 months, the older group of cases averaging 3.14 months and

those during the 1938 to 1945 period averaging 2.45 months. This would seem, at first glance, to be a reasonably short period during which the patient practiced self-medication or merely made up his mind to see a physician.

Another interesting phase of this subject is the length of time patients were treated before the physician advised either x-ray studies, hospitalization or both. The longest period of empirical treatment was two years, which is obviously too long to

GASTRIC ANALYSIS

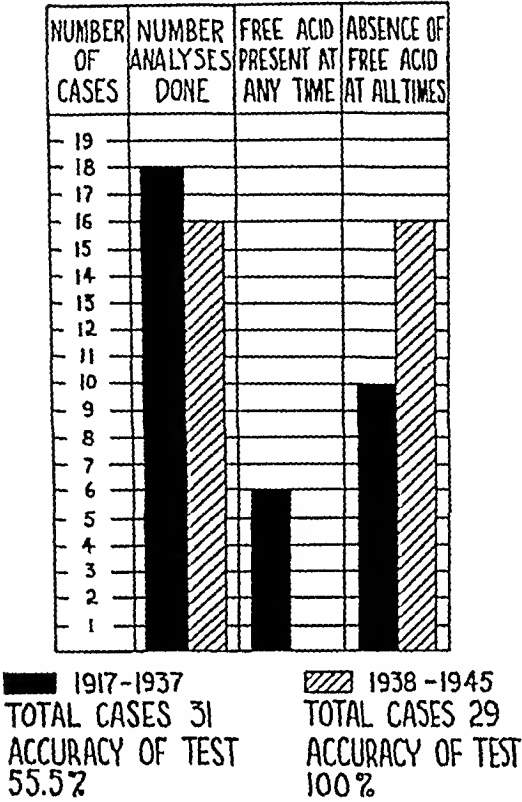


FIG. 3. Reveals increasing accuracy and importance of gastric analysis.

continue an unsuccessful regimen of therapy without seeking roentgenological evidence of a tumor. However, on the credit

TABLE III
SEX INCIDENCE OF CARCINOMA OF THE STOMACH

	1917 to 1937		1938 to 1945		1917 to 1945 Combined	
	No.	Per Cent	No.	Per Cent	No.	Per Cent
Males.....	20	64.5	16	55.2	36	59.8
Females.....	11	35.5	13	43.8	24	40.2
Total.....	31	100.0	29	100.0	60	100.0

side of the ledger, 36 per cent of all patients seen by physicians were treated less than a month before hospitalization or x-ray study was advised; in 16 per cent of all cases such advice was given immediately.

On the average, patients were treated only 12.4 weeks on a preliminary or trial basis. Here, again, is found what apparently should be a reasonably short period of treatment by alkali, bowel management, diet and other symptomatic measures. Unfortunately, the nature of this disease is such that physicians are still seeing late cases, not early ones, and are futilely referring such cases for surgical therapy.

TABLE IV
SINGLE MOST PROMINENT SYMPTOM OF PATIENTS
SUBSEQUENTLY DIAGNOSED AS CARCINOMA OF STOMACH

	No. of Cases	Per Cent
Chronic upper abdominal pain or ache	15	25.00
Vomiting.....	11	18.33
Acute abdominal pain.....	5	8.33
Indigestion.....	4	6.66
Discomfort following meals.....	4	6.66
Anorexia.....	3	5.00
Weight loss.....	2	3.33
Generalized asthenia.....	2	3.33
Hematemesis.....	2	3.33
Vertigo.....	2	3.33
Simple regurgitation.....	1	1.66
Flatulence.....	1	1.66
Jaundice.....	1	1.66
Diarrhea.....	1	1.66
Dysphagia.....	1	1.66
Masses in abdomen.....	1	1.66
Fullness in throat.....	1	1.66
Incoherent on admission.....	1	1.66
No gastrointestinal or abdominal symptoms.....	2	3.33
Total.....	60	100.00

Our statistics bear this last fact out completely. The average patient lived for only 8.12 months after the initial appearance of symptoms. This interval increased only 0.55 months from the old to the more recent group of patients. The size of the tumor, described under *Pathology*, is further evidence of the advanced stage at which cases are seen, as is the high rate of metastases.

Physical Examination. It is generally acknowledged that ordinary physical diagnostic methods cannot be applied practically with any modicum of confidence in diagnosing an early carcinoma of the

DISTRIBUTION OF METASTASES

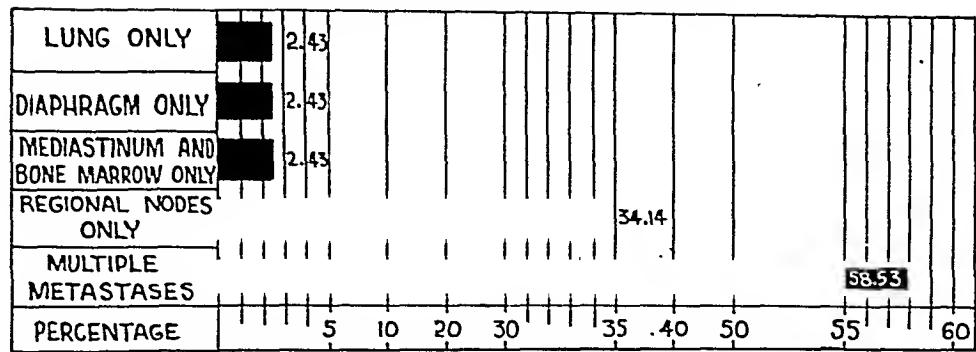


FIG. 4. Showing the extremely high rate of multiple metastases and consequent futility of attempting curative surgery in most cases.

stomach. The presence of an abdominal mass or a palpable metastatic supraclavicular lymph gland is a gross sign of incurable disease. Therefore, physical findings are not particularly important for the purposes of this discussion.

Laboratory Procedures. The absence of free hydrochloric acid is still perhaps the most helpful laboratory finding. There has been an increase in the reliability of the test even though methods have changed but little. (Table v, Fig. 3.)

TABLE v
GASTRIC ANALYSIS

	1917 to 1937	1938 to 1945
Total Cases.....	31	29
Analyses done.....	18 cases	16 cases
Free HCl before and after test meal	6 cases	0 cases
No free HCl on fasting specimen, but after test meal or histamine..	2 cases	0 cases
No free HCl before or after test meal or histamine.....	10 cases	16 cases
Presence of blood in specimens....	.....	7 cases

Macrocytic anemia of the hyperchromic type described as occurring in carcinomas which destroy gastric mucosa was not evident in these cases despite the large size of some of the growths. Some degree of anisocytosis and poikilocytosis was observed, but no anemia of the "pernicious anemia type" was found. The average hemoglobin determination was 63.7 per cent of normal, and the average erythrocyte count was 3.6 million cells per cubic

millimeter. This yields a color index which is in no way remarkable.

Examination of feces was not particularly helpful in most cases, nor was the leukocyte count of value in diagnosis.

Roentgenological Studies. The prominent place of x-ray in the diagnosis of cases of carcinoma of the stomach is undisputed. The usual methods, that is, fluoroscopy and multiple films, have not changed radically in recent years. From our 1917 to 1937 cases twenty-four out

TABLE VI
X-RAY STUDIES

	1917 to 1937	1938 to 1945
Number of cases in which x-ray studies (G-I series) were made.....	28	19
Number of cases in which x-ray suggested diagnosis.....	24	18
Number of cases x-ray failed to show lesion at a time when symptoms were present.....	4	1
X-ray accuracy (per cent).....	85.7	94.8

of twenty-eight barium meals suggested the diagnosis which was ultimately proved at operation or autopsy. This represents x-ray accuracy of 85.7 per cent. This is quite a good record, particularly so since the earlier years are included. Of the four cases not diagnosed by x-ray during this period one was a colloid carcinoma; the second was an adenocarcinoma, grade iv on the posterior wall of the stomach;

OPERATIVE RATES AND TYPES OF PROCEDURE

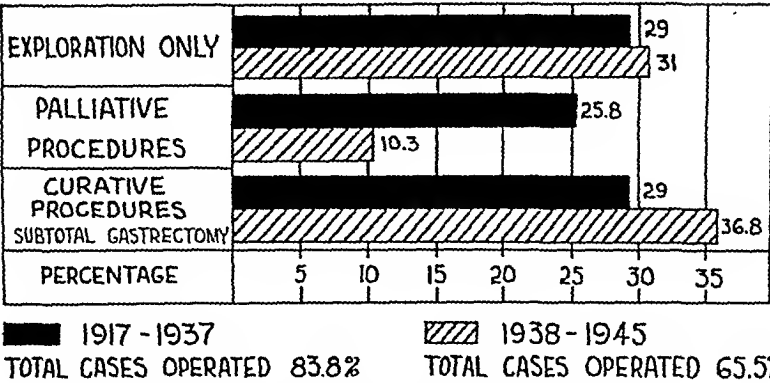


FIG. 5. This chart reveals an excessively high operative rate, but a reasonable gastrectomy rate.

the third was a carcinoma of undetermined type situated one-half way between the cardiac and pyloric orifices; and the fourth case was an adenocarcinoma, grade III, located in the antrum and pyloric regions. There seems, from these cases at least, to be no particular tumor site or type of histopathology which consistently evades x-ray diagnosis. During the past seven years the x-ray accuracy has been elevated to 94.8 per cent, with only one case of nineteen being missed. The error was made in a case which presented an adenocarcinoma, grade III, located in the pyloric antrum.

In four cases the x-ray report was inconclusive when the first study was done, the diagnosis finally being arrived at by repeated gastrointestinal barium series. This is a further argument for using a laboratory method as an aid, not as a final answer. Also, it serves to emphasize the importance of repeating a negative test because of the persistence of symptoms. (Table VI.)

Pathology. Two-thirds of all the cases were found to be primary adenocarcinoma. Of these two-thirds, one case revealed concomitant primary carcinoma of the rectum. Three of the adenocarcinomas were of the linitis plastica type, and two of the tumors originated within pre-existing polyps.

Of the other 33.3 per cent of all cases, there were only two scirrhus carcinomas

and one case diagnosed as carcinoma simplex. There was one, also, called simply colloid carcinoma. In sixteen cases no positive microscopic diagnosis was made.

One case, included among the adenocarcinomas, was found to arise from Brunner's glands of the duodenum. Another adenocarcinoma presented a superimposed abscess.

TABLE VII
METASTASES
Occurrence of Metastases

1917 to 1937	
Metastases (demonstrable).....	25
No demonstrable metastases.....	6
1938 to 1945	
Metastases (demonstrable).....	16
No demonstrable metastases.....	13

Distribution of Metastases 41 Cases (1917 to 1945)

	No.	Per Cent
Regional nodes only....	14	34.14 of metastatic cases
Lung only.....	1	2.43
Diaphragm only.....	1	2.43
Mediastinum and bone marrow only.....	1	2.43
Multiple metastases....	24	58.53
		100

The average diameter of all lesions was slightly greater than 7 cm. This seems rather large but is in keeping with the high mortality rate. It is remarkable that tumors should attain such size without creating earlier symptoms. There is no

apparent correlation between the size of tumors and the type of histopathology.

The pathological picture and, by consequence, the prognosis, is made even less hopeful when the occurrence of metastases is considered. Only 31.6 per cent of the cases were apparently free from metastases by gross examination before and during operation. In other words, over two-thirds of the cases revealed metastatic carcinoma at a time when surgical cure was to have been attempted. Of these, 58 per cent of the patients had multiple metastatic lesions. (Table VII, Fig. 4.)

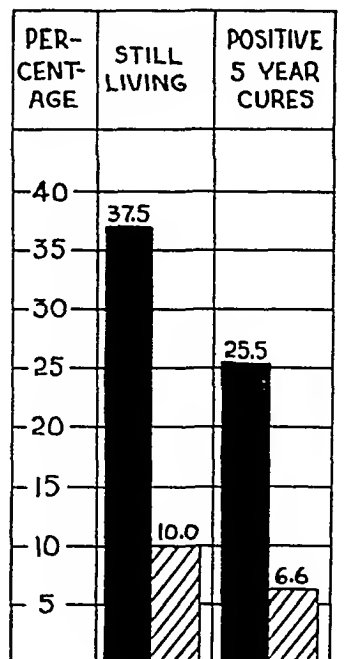
These discouraging points are brought into even sharper focus and are adequately explained by a consideration of the type of tumor cells which form a carcinoma of the stomach. The extreme anaplasia is evidenced by the fact that twenty-five out of sixty cases were described by the pathologist as grade III or grade IV malignancies.

Operative Therapy. In the light of the present knowledge of malignant gastric growths it is obvious, and universally accepted, that the only worth while treatment is surgical treatment. In other words, the only hope for cure is radical excision of the tumor and, if ablation proves impossible, a palliative procedure frequently is indicated. Palliative procedures are done most often for obstructing carcinoma near the pyloric or cardiac orifice; for the former, gastroenterostomy is done, and for the latter, simple gastrostomy.

Of the thirty-one cases from 1917 to 1937, a total of twenty-six patients were subjected to an exploratory operation. Such a high operative rate (83.8 per cent) is not justified when consideration is given to the high rate of cases explored only (29.0 per cent) and those eligible for palliative surgery only (25.8 per cent). This leaves only nine patients (29.0 per cent of total) on whom a curative operation was attempted. On 7.6 per cent no surgery of any kind was employed.

Of the twenty-nine cases from 1938 to 1945, a total of nineteen patients (65.5 per

MORTALITY RATES



■ OF 16 GASTRIC RESECTIONS
 ▨ OF 60 CASES TOTAL

FIG. 6. The mortality rates shown here are most depressing yet they are fairly typical.

cent) were operated upon. This represents a decline of 18.3 per cent over the earlier group even though slightly earlier cases probably were treated. Exploration only was done in nine patients (31.0 per cent), again a slight leaning toward a more conservative, if pessimistic, policy. On the other hand, only three (10.3 per cent) of the operations performed were palliative procedures. A total of seven (36.84 per cent) curative operations were attempted, an increase over those in the earlier group. (Fig. 5.)

Pólya type resections have been performed at this hospital since 1921. There has been little change in the actual technique since sleeve resections with gastroduodenostomy proved unsatisfactory and the various forms of Billroth II subtotal gastrectomy were substituted. There has been a gradual change from posterior to anterior (antecolic) gastrojejunostomy, however. The main reasons for this are

the ease and speed of an anterior anastomosis and the easier approach in possible secondary operations when the anterior is used. This is not considered to be a major point.

The results of curative surgery are poor. A total of six patients of the sixteen patients operated upon are still alive. This

SUMMARY AND CONCLUSIONS
Carcinoma of the stomach as seen, diagnosed and treated in a community hospital over a period of years has been considered. Cases have been carefully analyzed and reviewed in an effort to determine at what point in the disease an earlier diagnosis might have been made.

TABLE VIII
CARCINOMA OF THE STOMACH
1917 to 1938 (31 cases total)
Number of cases explored—26. Explored only—9. Number of palliative operations—8. Number of curative procedures—9
Synopsis of Curative Procedure Cases

Case	Year	Age	Sex	Site of Tumor	Type of Tumor	Metastases	Operation	Result
J. M. 12619	1921	44	F	Whole pyloric antrum extending to pyloric orifice	Carcinoma simplex	Right lower lobe 2-24-21	Partial gastrectomy and gastrojejunostomy (Pólya) 1-10-21	Died 11-16-21, 10 mns. after operation
E. J. 43988	1932	47	F	Posterior wall of pyloric antrum extending toward fundus	Scirrhus carcinoma, grade III	None seen at operation	Partial gastrectomy with gastroduodenostomy 9-8-32	In good health 7-6-37, 5 yrs. after operation
G. L. 44791	1932	68	M	Pyloric antrum	Adenocarcinoma, grade II	Regional lymph nodes	Partial gastrectomy and gastrojejunostomy 12-7-32	Died 12-10-32, operative death
B. F. 48469	1933	58	M	Pyloric region	Adenocarcinoma, grade III	Glands on greater curvature. Definite evidence of lymphatic invasion	Resection of stomach, gastroduodenostomy 11-9-33	Working 12-7-45, 12 yrs. after operation; feeling well
L. B. 55604	1935	54	M	Posterior wall (middle)	Scirrhus	Regional nodes	Subtotal gastric resection. Gastroenterostomy (Pólya) 8-26-35	Died 8-26-35, operative death
W. P. A-173 16004	1935	66	M	Antrom and pyloric region	Adenocarcinoma, grade III	Mesenteric nodes generalized carcinomatosis, liver gall bladder, pancreas, jejunum* No evidence	Partial gastrectomy, Pólya anastomosis, gastrojejunostomy 7-27-35	Died 2-16-36, 8 months
P. N. A-3609	1936	74	M	Anterior wall	Adenocarcinoma, grades III and IV	Regional nodes	Sleeve resection, 11-14-36	Able to get along on careful diet 2 yrs. after operation
B. C. A-4091	1936	50	M	Middle third of greater curvature	Adenocarcinoma, grade III	Gastrocolic and gastroleptic omentum	Gastric resection and gastroenterostomy (Pólya) 12-12-36	Died 12-17-36
H. S. H. B-3172	1937	70	M	Distal 5 cm. and pyloric region	Adenocarcinoma, grades II and III		Gastric resection and gastroenterostomy (Pólya) 8-24-37	Died 8-26-37

* Only mesenteric nodes involved at operation. This patient died of recurrent carcinoma.
Number of five-year cures—2.
Number of operative deaths—4.

yields an apparent survival of 10 per cent. However, two patients have not yet reached the five-year postoperative stage, yielding a corrected positive survival of at least 6.6 per cent of all the cases analyzed. It is, nevertheless, 25 per cent survival among those cases on whom curative surgery was attempted. (Fig. 6, Tables VII and IX.)

The inevitable conclusion is that present methods are sadly inadequate, and this paper merely emphasizes such a conclusion. A similar and equally discouraging situation is evident in regard to treatment. Numerous types of gastric resection have been attempted with encouraging results only insofar as the immediate postoperative condition is concerned. Surgical cures

have, in the main, not been forthcoming, even though it is acknowledged that slight increases in five-year cures have materialized. The limitations of surgical therapy are inherent in the grossness of such a system, in spite of its obvious advantages, there are many facets which reflect waste and lost motion born of a lack of central direction of effort, frequent duplication of original work and a lack

TABLE IX
CARCINOMA OF THE STOMACH
1938 to 1945 (29 cases total)
Number of cases explored—19. Explored only—9. Number of palliative operations—3. Number of curative procedures—7
Synopsis of Curative Procedure Cases

Case	Year	Age	Sex	Site of Tumor	Type of Tumor	Metastases	Operation	Result
S. B. J-1670	1945	67	F	Duodenum	Anaplastic carcinoma	None	Gastrectomy, subtotal gastrojejunostomy, antecolic	Patient losing wt. Condition poor 1-21-46
M. T. H-3278	1943	61	F	Antrum of Stomach	Adenocarcinoma, grade III, "malignant polyp"	None	Gastrectomy, subtotal gastrojejunostomy, antecolic	Condition good. Patient feeling well 1-21-46
E. W. H-1186	1943	86	F	Pylorus	Anaplastic carcinoma, grades III and IV	Gastric and pancreatic lymph nodes	Gastrectomy, subtotal gastrojejunostomy, antecolic	Died 8-27-43 5 mos. after operation
K. R. 11506	1940	58	F	Pylorus	Adenocarcinoma, grades II-III	None	Transection of stomach Gastrojejunostomy, antecolic	Died, operative death
L. W. F-1094	1941	78	F	Pylorus	Adenocarcinoma	None	Gastrectomy, subtotal (pyloric antrum) Gastrojejunostomy, posterior	Died 1 yr., 9 mos. after operation
H. H. D-523	1939	72	M	Antrum of Stomach	Adenocarcinoma, grade II liver—III		Gastrectomy, subtotal Gastrojejunostomy, posterior	Died, operative death
M. B. D-83	1939	62	F	Near fundus	Adenocarcinoma with secondary abscess	None	Gastrectomy, subtotal Gastrojejunostomy, posterior	Patient living and well 1-19-46

the available diagnostic aids and, more particularly, the absence of early symptom development.

Many groups of capable internists and surgeons have long pondered these depressing facts. It seems logical to assume that the present approach to this malignant disease will never yield satisfactory results. Small groups working along either parallel or divergent lines of cancer research represent the present method of attack. In of sufficient funds. In view of these conditions, would it not be more logical to concentrate and centralize all funds, equipment, case material and personnel available for cancer research? Such a course seems, to the authors, to be reasonable and more economical. We believe that a greater mathematical probability of developing an answer to carcinoma of the stomach would obtain under a system of co-ordinated research.



SKIN DRESSINGS IN THE TREATMENT OF DÉBRIDED WOUNDS

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THE work represented by this paper was done during the interval of June 1943 to March 1945, and includes the African, Sicilian, Italian, and French Campaigns.

Two series of cases are reported, one of which was done on injuries which were four to six months old. The second series was on patients whose injuries were four to ten days old. The two series of cases were completed by November, 1943, but the principles which are suggested, have been followed continuously since that time whenever applicable.

The purpose of this work is to show the use of split thickness skin grafts for battle injuries which have been débrided in forward installations, usually field or evacuation hospitals, and which are not readily amenable to secondary closure.

At the beginning of the African Campaign immediate débridement was the first surgical treatment given to these injuries. In many instances complete excision of the total area was practiced, which involved considerable loss of skin.

The function of the split thickness skin graft is to convert the large open wound into a closed healing wound as rapidly as possible. In accomplishing this end bed patients are quickly made ambulatory. In many instances combat soldiers are able to return to full duty. Patients who are to be evacuated to the Zone of Interior, over a long chain of evacuation, become much less of a nursing problem after having had these grafts.

The use of skin grafts to convert large soft tissue injuries, which have associated fractures of the long bones, into closed wounds has also been accomplished. This series of cases will be reported later.

The value of the early closure of these defects is of great importance to the orthopedic and reconstructive surgeons. By this means early operative procedures, such as bone plating or nerve repair, can be done through clean operative fields at a much earlier date.

The adequate use of split thickness skin grafts by orthopedic and general surgical services is to be encouraged. The majority of battle injuries involve extremities, and are, therefore, treated by orthopedic or general surgical services in evacuation or field hospitals. The continuation of treatment falls to the same services in the rear echelon hospitals. There is an insufficient staff of qualified plastic surgeons to care for the volume of this work over an extended area. Therefore, if the maximum number of injured are to be afforded this treatment, it would be necessary for the services handling these cases to resort freely to the use of skin grafts.

The objective, therefore, has become a problem of conversion of an open wound to a closed wound, and this is done without regard for function or esthetic appearance. The latter two factors are delegated to reconstructive surgery done in the Zone of Interior, and are purposely omitted in this paper.

The term "skin dressings" was advocated at the completion of the first series of cases, in June 1943, at a hospital in the African Theatre.

At that time a survey of the surgical patients, in the above mentioned hospital, revealed 2500 cases, checked either by record or through the daily surgical clinic. Of this number there were found to be 115 cases, who after four to six months' hospitalization, still had persistent, open

lesions, the chief defect of which was the absence of skin. Histories of the individual cases revealed that many of these wounds had reached a stagnant stage in healing and were being dressed bi-weekly. In some cases complete coverage had taken place, lasting for a period of one to seven days, with subsequent breakdown of the original wound. These areas varied in size from 5 to 15 cm. in length. Investigation by x-ray revealed foreign body inclusions in only a small number of cases.

During the month of June, 1943, thirty of these patients were operated, with resultant 90 per cent complete recovery. A check-up at the end of six weeks showed no breakdown of any of the wounds.

Before completion of the 115 cases, the battle front was moved to the Sicilian Invasion, and a continuation of this work was transferred to a station hospital in the Bizerte Area, which was receiving casualties on the fourth to the tenth day after injury. These fresh injuries were similar to the above mentioned old injuries, except for the time element. Had they been allowed to go unoperated upon the same condition, described above, would have resulted in the same period of time.

Seventy-one patients were operated upon during July and August, 1943. The areas involved were primarily on the extremities which had been débrided, dusted with sulfanilamide powder, and a vaseline gauze dressing applied in a forward installation.

On admission, many of these cases were classed as dirty wounds, having moderate surface infection, but relatively little spreading infection. In some, moderate fascia or tendon sloughs existed. In all of them, there was a definite tendency for profuse exudation to be present.

The majority of the cases were wet packed for twenty-four to forty-eight hours with saline packs or saturated solution boric acid packs. At the end of that time the surface infection appeared visibly diminished.

Regardless of size, depth, or basal conformation, all areas were immediately

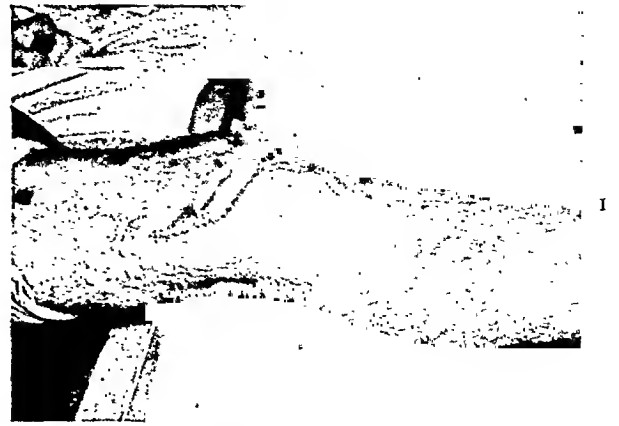


FIG. 1. Unhealed granulating wound of twenty-six days' duration.



FIG. 2. Split thickness skin graft at forty-eight-hour dressing. Sutures have been removed.

covered with split thickness skin grafts, obtained after the Blair technic. Wounds having stellate lacerations along the margins were closed as much as possible by interrupted suturing with black silk, before applying graft to the remaining areas. The dependent portions of the wounds, or lateral areas of undermining which were produced in some instances by the partial secondary closure, were drained by means of small strips of rubber dam drain. In several instances, holes were made through the sheet of graft, so that a drain could be placed in a cavity or recess through the graft.

Muslin strips, lightly coated with vaseline, were applied to all grafts in terrace fashion whether sutured or just laid on the defect, followed by the application of sponges, waste, or ABD pads. A pressure bandage was next applied, followed by complete adhesive strip covering. Im-



FIG. 3. Split thickness skin graft applied to "v"-shaped wound of thigh (fifteen days after application).

mobilization was accomplished where advisable, by light plaster splints. Ace bandages or stockinette can be used satisfactorily.

In the first wounds grafted, the dressings were left undisturbed ten to fourteen days, but in all of these an excessive amount of exudation was evident, and it was believed that a portion of the grafts were lost because of this.

By trial and error method, it was found that 80 to 100 per cent take of the grafts was obtained, if dressings were changed at forty-eight-hour intervals. Those cases with moderate surface infection were continued on wet packs during the dressing intervals. All dressings were done in the operating room, because of the excessive dust and wind of that location during that season.

It was found that complete healing occurred as early as fourteen days, but the average for the entire group was twenty-eight days.

By this time all patients without lower extremity fractures were ambulatory. Those with complicating factors, demanding Zone of Interior evacuation, left the



FIG. 4. Irregular stellate wound with uneven trough-like base. Partial closure and graft were done simultaneously; appearance on fifteenth postoperative day.

hospital with all areas healed and covered with skin. Many patients returned to full duty.

Tabulated estimations of the results of "take" of the grafts are as follows: Complete take sixty-two or 87 per cent; partial take (50 per cent or over) three or 4 per cent; total failure six or 8 per cent.

COMMENTS

These split grafts were applied with the sole intent of giving skin coverage to open wounds. In some areas the grafts were placed directly in contact with fascia, muscle belly, or exposed periosteum, according to the amount of soft tissue loss.

It must be repeated that neither the functional nor the esthetic end result was given a place of primary importance.

During the course of this work, several clinics were held, and cases both good and bad demonstrated. The predominant question raised was "Why are not most of these cases suitable for secondary closure?"

Some of them may have been, but not without wide undermining of skin margins, which open possibilities for additional infection in an already infected wound. The grafts were placed on the wounds in the presence of this infection, knowingly.

It is good reasoning that any area which can be closed secondarily, is in better condition than a grafted area; but most of the wounds so grafted were large, excised, avulsed or saucerized lesions which would have been exceedingly difficult otherwise. There is every reason, therefore, why this procedure should act as a complement to the General Surgical Service instead of over-riding it.

Another question was "gas gangrene possibilities." The observation is made that the optimum time for these grafts is between the fifth to the tenth day after injury. Preliminary, adequate débridement plus the use of penicillin, in questionable cases, has kept the number of cases of gas gangrene at a minimum. Some cases of gas have developed as late as thirty days after injury in wounds secondarily closed. These are the exceptional cases and cannot be foreseen. No reports are on record of gas gangrene in a grafted extremity thus far observed.

The clinical appearance of the patient, and the wound, was examined thoroughly before grafting, but bacteriological studies of the wounds were not done. Those wounds which visibly were extremely infected responded satisfactorily to wet packs over a twenty-four to forty-eight-hour period preoperatively. Grafting was not delayed beyond forty-eight hours because of infection, or even moderate sloughing of underlying structures.

To verify these findings, the general surgical service was asked to cooperate. They chose fourteen cases which were not suitable for secondary closure. Of these, thirteen were entirely successful while one failed.

During this period, the services of the Army Pictorial Service were available for a limited period of time, on limited

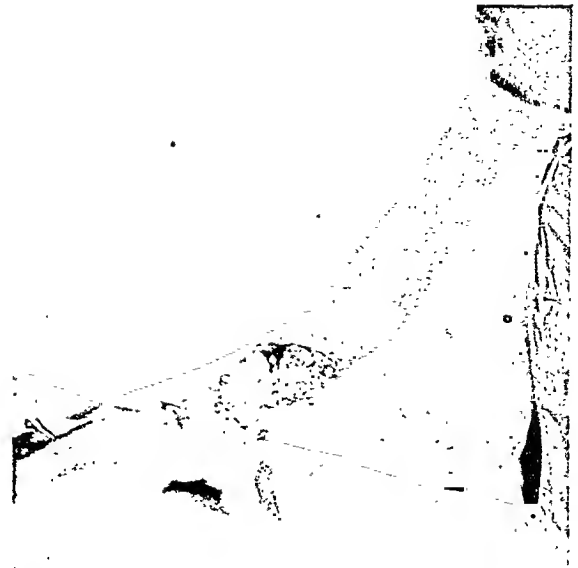


FIG. 5. Combination procedure of sliding flap graft, partial closure, and split thickness skin graft with drainage by tissue dam at time of grafting; appearance on tenth postoperative day.

occasions. Films were obtained on six cases. These cases are given briefly as follows:

CASE REPORTS

CASE 1. This case represents the type of lesion seen in the late stages of healing, and such as was found in the original survey. The original injury was twenty-six days prior to admission to this Hospital, and was a shell fragment laceration.

At the present time (Fig. 1) there is a painful, unhealed area on the medial aspect of the left knee, which according to the history has reached a stagnant period of recovery. There is a weeping granular base present in the center. This area is small in comparison to the greater number of cases operated, but is one of the few in which both pictures are available.

By comparison, it is estimated that an additional twenty to thirty days would be required for healing.

The margins of skin were excised and the base scraped lightly. A split skin graft was applied. Figure 2 shows the extent of excision and the condition of the graft at the end of forty-eight hours. Sutures have been removed. Several small stab drain areas can be seen in the graft. This patient was entirely healed in sixteen days. He returned to limited duty in twenty-six days.



FIG. 6. Large irregular defect $1\frac{1}{2}$ inches deep completely covered by split graft, which was applied directly to muscle belly and fascia; appearance on sixteenth postoperative day.

CASE II. This patient was admitted to the Hospital eleven days after injury by a shell fragment, which tore medially across the thigh and avulsed a section of skin and partially transected the quadriceps muscle. There was gross infection present. The first treatment had been débridement, application of sulfonilamide, and vaseline gauze dressing lightly applied. He received boric acid packs for twenty-four hours preoperatively. Under spinal anesthesia a split skin graft was taken from the right thigh and applied to the depressed wound. Sutures of black silk were used. He was dressed at forty-eight-hour intervals and by the thirteenth day was healed and ambulatory.

The graft (Fig. 3) is adherent to both muscle and fascia. Movements of the leg are not limited or painful. On the fifteenth day, when the photograph was made, the patient was assisting with ward work. This is not a desired esthetic result, but the function is satisfactory and the area is without pain.

CASE III. This patient was admitted to the hospital on the seventh day after injury. A shell fragment had lacerated the left gastrocnemius area. Primary treatment had been débridement and application of vaseline gauze dressings. There was moderate infection present and also some slough of muscle fibers and fascia on admission. Preoperative treatment of forty-eight-hour boric acid packs was used.

The operation consisted of secondary closure of the medial and lateral stellate areas of the wound, using black silk. The remaining area was covered with split skin graft, with a small

tissue drain in one dependent area of the middle of the graft. This was done under spinal anesthesia. Figure 4 was made on the fifteenth postoperative day. Irregular depressed areas in the middle of the graft are still visible. He was ambulatory on the seventeenth day and was discharged on the twenty-fifth day.

CASE IV. This patient was admitted to the hospital on the eighth day after injury. There was an extensive and deep soft tissue injury of the left mid biceps region, with both the biceps and triceps visible. There was infection and slough present on admission. Primary treatment had been débridement, sulfonilamide powder, and vaseline gauze dressings.

The operation consisted of a sliding full thickness graft from the lower portion of the wound, which was advanced superiorly to meet the secondarily closed upper area. A drain was inserted at this junction. The lower portion, which included part of the original wound, was covered by a split graft. Two small drains were brought through the graft in this area. Dressings were at forty-eight-hour intervals. There was complete healing in eighteen days. Complete function existed in twenty-eight days. Figure 5 was taken on the tenth postoperative day.

CASE V. This patient was admitted to the hospital fourteen days after injury. He had a large avulsed area of the inner aspect of the right thigh produced by a shell fragment. There had been wide incision and débridement of the area. The wound appeared to be at least one and one-half inches deep. Moderate surface



FIG. 7. Irregular stellate wound with partial avulsion of portion of first metatarsal, exposing periosteum and bone.



FIG. 8. Split graft applied to "v"-shaped defect, directly in contact with periosteum and bone; entirely healed on fourteenth postoperative day; appearance on fourteenth day.

infection was present. He received boric acid wet packs for forty-eight hours preoperatively.

The operation consisted of the application of a large split graft removed from the opposite thigh. This was sutured with black silk. Three drains were used through the graft and several small stab drains were cut in the graft. Spinal anesthesia was used. The graft was healed in sixteen days with exception of three or four small buds of granulation which protruded through the stab drain areas. These quickly bridged. (Fig. 6.) The patient was discharged to light duty on the twenty-third postoperative day.

CASE VI. This case, though small, is shown because of its relationship to orthopedic problems. The patient was admitted to the hospital on the ninth day after injury, received from a personnel mine. On admission there was moderate infection present, in the injury of his left foot. He had had a débridement, sulfonamide powder, and vaseline gauze dressings as a preliminary treatment. The injury avulsed a section of the first metatarsal and that area is visible in Fig. 7. The lesion extended onto the plantar surface of the foot. He received wet boric acid packs for forty-eight hours preoperatively.

The operation consisted of partial secondary closure of the plantar surface, and the application of a split graft into the V shaped wound of the medial border. There was no excision or débridement at the time of operation.

Figure 8 was made on the fourteenth post-

operative day, and shows the graft entirely taken even over the area which showed exposed bone and periosteum.

This patient was scheduled for Zone of Interior evacuation, and was evacuated with completely healed wounds, which did not require additional nursing care.

SUMMARY

A series of 101 cases of the application of split thickness skin grafts is reported.

Six of these cases are reported in brief with photographs.

These cases show 87 per cent successful takes of the grafts.

The relationship of this work to general surgery and to orthopedic surgery is discussed.

The entire effort is based on an attempt to convert large tissue defects, received in war injuries, into rapidly healing closed wounds, which shortens the patient's period of hospitalization and convalescence, and returns him early to limited or full military duty, or allows for more comfortable evacuation to the Zone of the Interior.

CONCLUSIONS

The optimum time for the use of split skin grafts as a "skin dressing" to large

tissue defects, received as war injuries, is between the fifth to the tenth day after injury.

These grafts are practical in the presence of excessively exuding wounds, and also in the presence of mild surface infection.

These grafts may be used as combination procedures involving drainage of dependent areas, partial secondary closures, and skin grafting.

A dressing program of forty-eight-hour intervals seems to offer the greatest opportunity to combat excessive exudation, which is a predominant feature of massive war wounds; this technic offers most protection to the grafts applied.

Grafts used for this purpose should be very thin, since the thin split thickness graft shows a higher percentage of complete takes, in the presence of excessive exudation or moderate infection, than the deep intermediate grafts.

The donor areas of thin grafts are less

likely to become secondarily infected and heal without delay.

Failure of these grafts is attributed to retained foreign bodies, and/or excessive infection as a result of deep penetrating wounds, not thoroughly opened in the primary débridement of the wound, or missed, during inspection of the wound.

These grafts are not to take the place of secondary closures, but serve as an adjunct to general and orthopedic surgery in the care of war injuries which involve massive loss of skin surface.

The time necessary for the consummation of this work lies within a thirty-day period. It is, therefore, applicable in any installation which is functioning on a thirty-day, or more, basis.

The potentialities of the use of split thickness skin grafts, applied early in the treatment of war wounds, should be easily transcribed to traumatic surgery of civilian practice.



REGIONAL ANESTHESIA*

ITS ADVANTAGES IN EMERGENCY SURGERY OF THE EXTREMITIES

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THE success or failure of any surgical procedure depends in no small measure on the suitability of the method of anesthesia employed; and the comparatively large number of methods and agents of anesthesia in use today is proof enough that there is no such thing as the ideal and universal anesthetic suitable to all patients and all conditions.

Ever since the epoch-making discovery of the anesthetic powers of ether by Morton and Long nearly one hundred years ago, until the comparatively recent introduction of spinal anesthesia, general inhalation anesthesia has held the field. It has, however, in the past two decades largely given ground to the method of spinal anesthesia or spinal cord block. In some of the best known surgical centers today the majority of lower extremity and abdominal operations, and much of the major surgery of the thorax, are done under spinal anesthesia. While on no account trying to minimize the unprecedented boon that inhalation anesthesia has proven to be, one cannot help pointing out that it seems unjustifiable in some of the shorter and more restricted operations and manipulations to induce unconsciousness and anesthesia of the whole body when only the restricted field of operation need be rendered insensible. This is particularly true of emergency surgery in which, owing to the curtailment of time, some of the important factors in the routine preparation for general anesthesia, such as the empty stomach and thorough evaluation of the constitutional status, must of necessity be dispensed with.

In this article, it is proposed to point out some of the advantages that pertain

to the use of regional anesthesia in particular as it applies to the emergency surgery of the extremities.

Anesthesia of a region of the body may be achieved by regional nerve block, field block or local infiltration. Regional nerve block is at its best in operations on the extremities, head and neck. Field block, or the creation of a zone of anesthetized tissue in which are included the nerves to the part, between the central nervous system and the field of operation, has its greatest usefulness in operations on the thorax or abdomen. Local infiltration may be used in any region of the body. Certain objections are made to its use in any condition involving infection or contamination of the part being operated upon. The flooding of the tissues and consequent opening up of the tissue spaces by the anesthetic fluid in the region of infection or contamination (as in the case of a dirty wound), is believed by many to favor spread of infection or contamination to hitherto unaffected parts of the anatomy. Moreover, one is loath to plunge an infiltrating needle through the skin of the injured hand or forearm, the cleansing of which has been necessarily incomplete due to the pain involved. No such objection exists to injection of the brachial plexus through the skin of the supraclavicular fossa, which, being remote from the injured area, can be scrubbed as thoroughly as necessary. For this reason, as well as the more widespread, complete, and efficient anesthesia achieved, regional anesthesia is believed to be preferable to local anesthesia in operations on the extremities.

Field block or local infiltration may occasionally be used with advantage to

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supplement or reinforce the regional form when a certain plan of procedure is adopted. This involves the establishment of anesthesia of the part by the regional nerve block whereupon thorough cleansing of the traumatized region can be carried out painlessly. The nerves to certain isolated areas of the field of the operation may have been only lightly touched by the regional block higher up, and the anesthesia may begin to wear off early in these areas; but with the part now thoroughly clean, there is no objection to the use of a supplementary field block somewhat proximal to the operative field, or even local infiltration, to render these parts again insensible. Such reinforcement, however, should be unnecessary as a general rule.

One might mention some of the less important points in favor of regional anesthesia. Throughout the operation one has the cooperation of the patient, a factor of some importance in operations such as tendon or nerve suture. One may make use of electrocoagulation for the rapid and efficient control of bleeding in large wound surfaces since the risk of explosion is not present. Furthermore, on grounds of economy alone, the argument is strongly in favor of regional anesthesia. Certain advantages seem to pertain to the use of regional anesthesia in traumatic surgery. The simple nature of the equipment required makes the method suitable for all types of practice. It is universally admitted that early operation is of prime importance in dealing with wounds and it is believed that operation can be undertaken sooner with greater safety in these cases if one uses the regional method of anesthesia.

One should consider certain possible objections to the use of regional anesthesia. The most often quoted objection is the high percentage of cases in which inadequate anesthesia is attained. A moment's consideration will show that this objection derives not from the method but from the person using or rather misusing the

method. Anesthesia is undeniably adequate when the anesthetic fluid is brought in contact with the nerve or nerves to be blocked and if anesthesia is not obtained it means that this essential was not obtained. Thus absence or insufficiency of anesthesia is due not to a fault of the method but rather to a fault of the operator. Allowing for the very small percentage of cases in which the large nerve trunks lie in unusual situations, the finding of the nerves with the needle point constitutes no problem for anybody with an average knowledge of anatomy who is guided by the rules of the technic. Certain other objections may be offered such as the possibility of the patient being sensitive to novocaine, the most frequently used agent for regional anesthesia. This sensitivity is so rarely met with as to be of very little consequence. Moreover, it is recognized early and rarely constitutes a danger to life. One does occasionally encounter transient tachycardia, tremor and feelings of nervousness. These signs are less frequently seen if preliminary sedation and barbiturate (nembutal) is adopted. They rarely require any active measures to combat them, but a few cc. of intravenous barbiturate (pentothal sodium) will quickly control a reaction of any magnitude. There is, of course, the possibility of the injection of novocaine into a vein by a careless operator with resulting circulatory collapse. This is easily avoided by exercising average care in technic. One should never inject novocaine into the tissues without applying the aspiration test, i.e., withdrawing the plunger of the syringe a little before injecting. If the point of the needle is resting within the lumen of a blood vessel, blood will be drawn into the syringe.

The question of injury to the deeper structures is of more importance in the case of brachial plexus block than in sciatic block. The subclavian artery has been punctured several times in the present series but in no case has any permanent damage resulted, and the accident has never constituted anything other than a

nuisance. It usually occurs toward the end of the injection as the lower trunk of the plexus is being searched for. It is more of a problem in those rare cases in which it occurs early in the course of the injection in that the resulting hematoma obscures the field and renders the aspiration test useless. It is, therefore, recommended that the injection be abandoned in such an instance.

A more formidable complication is injury to the underlying lung with resulting pneumothorax which, depending on the wound in the lung, might be of the tension variety. Pneumothorax of a very limited extent occurred in a block done for open reduction of a fracture of the olecranon process of the ulna. That case is not included in the present series because it was not an emergency operation. Two hundred cc. of air were aspirated from the left pleural cavity at once, the patient was returned to the ward and no further trouble resulted. Such a complication should be rarely seen and should be easily dealt with when it occurs.

It is a fact that a certain small percentage of patients, by reason of their mental make-up, are unsuitable for the exhibition of any form of anesthesia other than the general type. These patients, an extremely small minority, are not capable of standing the strain of being operated upon while retaining full consciousness. Even after the administration of powerful doses of the usual sedatives they are still so overcome by fear of the suffering which they anticipate, that they cannot or will not adjust themselves to the method. A considerably larger number of patients of a nervous disposition also are not ideal subjects for local, regional or spinal anesthesia. In these cases, however, the difficulty can be readily overcome by the administration of adequate doses of the usual sedative drugs. Even for the average patient, preliminary sedation in considerably larger dosage is required when subjected to operation under the influence of local, regional

or spinal anesthesia than would be the case were the anesthetic a general one.

An important general principle should be stated here: Regional anesthesia is at its best when only one region of the body is being operated on. The more regions that require anesthesia the less suitable becomes the regional and the more suitable becomes the general method, speaking from the purely anesthetic standpoint. In this account which deals only with the surgery of the extremities, two regions will be dealt with specifically: (1) the upper extremity distal to and including the shoulder joint, and (2) the lower extremity distal to and not including the knee joint.

For (1), block of the brachial plexus in the supraclavicular fossa is usually adequate. In the occasional case of wounds of the skin and subcutaneous tissues high up in the region of the point of the shoulder, a supplementary field block of the supraclavicular and supraacromial branches of cervical nerves three and four is indicated. In superficial wounds of the inner part of the upper arm, the intercostobrachial nerve can similarly be interrupted easily by a half-bracelet type of subcutaneous field block proximal to the seat of the injury on the inner hemi-circumference of the arm.

For (2), block of the great and small sciatic nerves in the gluteal region is adequate usually. The small sciatic nerve (posterior cutaneous nerve of the thigh) lies on the great sciatic nerve in the gluteal region and both nerves are blocked by the same injection. In an occasional case with wounds of the inner side of the leg and proximal part of the inner side of the foot, a supplementary half-bracelet subcutaneous field block of the inner hemi-circumference of the leg to interrupt the long saphenous nerve will be required. The lower extremity above and including the knee joint is less suitable for regional anesthesia than regions (1) and (2) because its nerve supply is less compactly arranged.

PRELIMINARY SEDATION

The importance of the preliminary sedation to the success of the method has been emphasized already, and some of the points which should be considered in order to determine the appropriate type and amount of premedication have been mentioned. Although it is impossible to give specific instructions here as to this aspect of the question for every particular case, the main points of importance will be mentioned and certain generalities will be stated about each.

A combination of barbiturate (nembutal) and morphia has been found to be the most satisfactory premedication. For the average 160 pound young adult male, 3 gr. of nembutal by mouth, together with $\frac{1}{4}$ gr. of morphine sulphine subcutaneously, are given one-half hour before the operation. For the average young adult female of 130 pounds the same time and the same dosage of morphia are observed, but only $1\frac{1}{2}$ gr. of nembutal are given. The range of dosage of morphia will vary from $\frac{1}{8}$ gr. to $\frac{1}{4}$ or even $\frac{1}{2}$ gr. in divided doses, and that of nembutal from $\frac{3}{4}$ gr. to 3 gr., depending on the following considerations:

Age of Patient. As a rule, the older the patient the less well are morphia and more especially nembutal tolerated, and fortunately these drugs are less necessary in the aged. For patients over fifty-five years of age the nembutal can usually be dispensed with and $\frac{1}{6}$ gr. of morphia alone will be found adequate. Children in their teens may be given $\frac{1}{6}$ gr. of morphia together with $1\frac{1}{2}$ gr. of nembutal.

Sex of Patient. Little difference has been found between the sexes in their suitability to regional anesthesia and the choice of the preliminary medication.

Weight of Patient. Other things being equal, the dosage is increased with increase in weight.

Mental Make-up of Patient. This is the most variable characteristic and also one of the most important to be considered in grading the dosage. The latter must be

appropriately increased in the apprehensive, excitable patient who may in addition be somewhat unbalanced as a result of the accident. An appropriate reduction can be made in the amount of the preanesthetic drugs in the case of phlegmatic individuals who have little fear of the operation, and who have accepted their accident as a nuisance rather than a calamity.

PRINCIPLES OF THE TECHNIC

The actual technic of the injection is best learned through a period of preliminary training under supervision on the living subject, or without supervision on the cadaver. There are certain inherent dangers in plunging a needle deeply into almost any part of the body, and the operator must know the dangers and how to avoid them. The best and safest place to learn the approach by needle to the deeper parts of the anatomy is in the dissecting room. Failing this, and not everybody has ready access to a dissecting room, the next best plan for the beginner in the use of regional anesthesia is to have practical instruction on the living subject from one who is already proficient in the method. However, the operator who carefully follows the rules of the approach will rarely if ever meet with serious trouble.

The most valuable guides by which one's path is directed in deep injections are constituted by the landmarks, superficial and deep, presented by certain parts of the bony skeleton. The superficial landmarks are those prominences easily palpable and occasionally visible which lie in the immediate neighborhood of the field of injection. Perhaps more important are the deep, bony landmarks which are not always palpable and never visible, but which can be sought out by the exploring needle point. The superficial landmarks constitute the rough guides to the approach. The deep landmarks, in that they lie nearer to the structure sought after, constitute the fine adjustment in the process. They have, however, an even more important function in that they often

constitute a protection and safeguard for the more vulnerable soft parts in the neighborhood. Thus, for example, in the case of brachial plexus block, the point of the needle is never intentionally allowed to deviate from the flat upper surface of the first rib which forms a convenient barrier of protection for the underlying pleura and lung. The outer, bony surface of the os inominatum similarly constitutes an efficient armor for the pelvic viscera in the case of sciatic nerve block.

Apart from the care needed to be taken with the actual injection, the surgeon operating with this method of anesthesia must of necessity be as gentle and painstakingly accurate in his movements as is humanly possible. All undue pulling or pushing will be a source of discomfort to the patient even though he does not feel any sensation of pain as such.

A practice must be made of checking on the adequacy of the preliminary medication shortly before the block injection is begun. Should the required state of oblivion be not attained at this time, the operation should not be proceeded with at once. An additional dose of morphia should be given and care taken that the patient is thoroughly under the influence before the needle touches the skin. Disregard of this precaution is one of the most frequent causes of failure or half success in the use of spinal, regional or local anesthesia. A convenient way of giving this eleventh hour sedation is to dissolve $\frac{1}{4}$ gr. of morphia sulfate in 2 cc. of normal saline. This is then administered intravenously in divided doses as required.

Another factor of considerable importance is constituted by the patient's immediate surroundings in the operating room. The whole atmosphere of the place must be as tranquil and quiet as possible. Imprudent rattling of the instruments or banging of sterilizing equipment may constitute a terrifying experience for the patients and is an unpardonable offense. Incalculable harm may be done by well meaning but imprudent queries such as

"does it hurt?" Even if it does not hurt, the putting of such a question suggests at once to the patient that he is being subjected to a procedure which ordinarily does hurt and in not a few instances he promptly obliges the questioner by feeling pain which does not exist. In the great majority of cases the patient will of his own accord readily let the operator know if he is experiencing pain. This is an instance of the power of suggestion acting in a deleterious sense. This same power can, however, be a great aid when used to supplement the method of regional anesthesia. If, in brachial plexus block, it is suggested to the patient that the nerves going to his upper limb are going to be injected "so as to make the whole arm and hand go to sleep" a valuable adjunct to the anesthetic power of the novocaine may be brought into effect.

DETAILS OF THE TECHNIC

In doing a nerve block one prefers to make the injection endoneurally or directly into the nerve trunks. By this method the most complete anesthesia is attained in the shortest time, usually within five minutes of completing the injection. A skillful operator will succeed in making the injection an endoneural one except in rare instances when, owing to obesity of the patient or to abnormality of the part, the nerves are not so readily accessible. In such instances one has to be content with a perineural injection, the anesthetic fluid being deposited in the immediate neighborhood of the nerves. If a sufficient amount of anesthetic fluid is injected near the nerves, the anesthesia will be quite adequate but will take longer to become established. In these cases one injects half as much anesthetic fluid again as is required for the endoneural block, and a period of twenty minutes is allowed to elapse before anesthesia is judged to be adequate.

A 10 or 20 cc. syringe with a hypodermic needle, and a No. 20 bore needle, one and one-half to two inches in length is



FIG. 1. Position for brachial plexus block.

required for the brachial block. For the sciatic block a much longer needle, four to five inches in length, is required. The usual lumbar puncture needle suits the purpose well. (Fig. 1.)

Brachial Block. Position: The patient is placed supine on the table with the arms by the side. The hand is grasped by an assistant and pulled toward the feet so as to depress the clavicle. The face of the patient is turned away from the side in question and the head is placed as far as possible to the other side. This gives a good exposure of the supraclavicular region.

Approach: The superficial landmark is the mid-point of clavicle; the deep landmark is the upper surface of the first rib.

The side of the neck and the upper part of the chest are then prepared with skin antiseptic. The supraclavicular region is draped with three linen towels, leaving the full length of the clavicle exposed. By palpating deeply above the middle of the clavicle one can feel the resistance offered by the flat upper surface of the first rib

at or about the junction of its anterior and middle thirds. At this point the rib curves backward around the base of the neck and is perhaps somewhat more medially placed than one would expect. The mid-point of the clavicle is identified and an intradermal wheal of anesthetic fluid is raised with the hypodermic needle just at the upper border of the clavicle at this point. The longer needle to which the syringe is attached is now plunged backward, very slightly inward, and slightly upward so as to impinge on the upper surface of the first rib.

Perhaps a good rule to follow in guiding the needle is to direct it at right angles to the line of the middle one-third of the clavicle, or more exactly at right angles to the plane of the anterosuperior surface of the middle one-third of the clavicle at its mid-point. It should be noted that the general line of the middle one-third of the clavicle is quite distinct from the line of the outer one-third, which portion curves rather sharply outward and somewhat anteriorly, and from the line of the inner one-third which runs outward and slightly posteriorly. The general direction of the middle one-third is outward and definitely posteriorly. Again, the clavicle at its mid-point has three surfaces: an anterosuperior, a posterior and an inferior. The above rule, taking into account the anterosuperior surface and middle third of the clavicle, while not mathematically accurate, will be found of considerable help in finding the upper surface of the first rib, while palpation of the rib is a further guide.

It must be emphasized that the whole success of the procedure, both for the accuracy as well as the safety of its performance, depends on finding the first rib and in not permitting the point of the needle to deviate past its flat upper surface. This is the important deep landmark which tells the operator where the point of the needle lies, and it is at the same time the barrier protecting the dome of the pleura, the apex of the lung and the

other important structures of the upper mediastinum.

In a majority of cases the point of the needle will strike the first rib less than 2 cm. lateral to the trunks of the brachial plexus where these structures cross the rib passing downward and outward to the upper extremity. Occasionally, the point of the needle will hit the plexus at once before it meets the rib and more rarely still the point of the needle will be placed medial to the plexus. As soon as the nerve trunks are touched by the needle the patient will feel a tingling sensation or "shock" down along the extremity in the distribution of the nerve touched.

Should the point of the needle not hit the plexus at its first insertion along the line indicated, the needle point is shifted gradually outward and backward along the surface of the rib for a distance of 1 to $1\frac{1}{2}$ cm. so as not to miss the plexus in those rare cases in which it is more laterally placed than usual. The plexus not being found in this region, the point of the needle is next moved in steps of $\frac{1}{2}$ cm. at a time medially along the surface of the rib and within a distance of 1 or 2 cm. of the point at which the rib was originally touched, the plexus will be found, and the patient will report the "shock." It should be noted that the brachial plexus in its relation to the first rib is placed lateral to the subclavian artery which is, in turn, somewhat lateral and posterior to the subclavian vein. Thus, if one moves the point of the needle in steps of a few mm. at a time inward along the rib, one must needs touch the plexus before one meets the subclavian artery. Thus it is that injury to the subclavian artery is made less likely in the same way as injury to the underlying pleura and lung is obviated by making use of the protection offered by the first rib.

The width of the plexus at this point varies from $1\frac{1}{2}$ to usually not more than 2 cm. In order to obtain the most rapid and complete anesthesia the full width of



FIG. 2. Position for sciatic nerve block.

the plexus must be infiltrated with the anesthetic fluid by inserting the needle into the trunks and injecting into them the anesthetic fluid until such time as no further sensation is elicited on touching the nerves. Thirty cc. of 2 per cent novocaine are used for the adult male. On entering one of the nerve trunks with the needle point one gets a sensation of increased resistance as compared with the sensation elicited in the surrounding tissues. Having injected the plexus for a distance of $1\frac{1}{2}$ to 2 cm. inward from the extreme outer limit at which the plexus was first encountered, one must be careful not to advance the needle point any further medially lest one should enter the subclavian artery. It should be noted that the anterior end of the first rib passes downward and inward deep to the clavicle; and as the lower trunk of the plexus is injected, the point of the needle will be directed backward slightly inward and increasingly downward deep to the clavicle.

Sciatic Block. Position: The patient is placed prone on the table with a pillow under the head, the face being turned to one side. (Fig. 2.)

Approach: The superficial landmarks are (1) the posterior superior spine of the ilium and (2) the tip of the great trochanter of the femur; the deep landmarks are the outer surface of the os inominatum as constituted by the lower dorsum ilii and upper ischium, where these bones form the bony limits of the great sciatic notch.

The buttock is widely prepared with skin antiseptic and draped with three linen towels. The posterior superior spin of the ilium is usually not a visible prominence but it can, nevertheless, be easily palpated. Less distinct by palpation is the summit of the great trochanter of the femur, which can be felt as an indistinct mass, but it is not necessary to be geometrically accurate with these superficial landmarks. These two prominences are marked by finger and thumb of the left hand and joined by an imaginary line. A second imaginary line is drawn at right angles to the original line at its mid-point. A point two finger breadths caudal to the point of intersection is then taken on the second line. This is the point of entry of the needle. The usual skin wheal is raised at this point by injecting a small quantity of anesthetic fluid under the epidermis, using the hypodermic needle.

The lumbar puncture needle is now plunged vertralward and slightly cranialward more or less at right angles to the skin until the point touches the lower dorsum ilii. The point of the needle is now moved directly medial in steps of $\frac{1}{2}$ cm. Occasionally, the great sciatic nerve will be met with by the needle point before the edge of the greater sciatic notch is reached. Presently the needle point will be felt to slide over the bony edge of the great sciatic notch toward the inside of the pelvis. The needle is at once withdrawn a little and its point is then moved step by step caudalward along the edge of the notch, slipping now and again off the edge until the great sciatic nerve is touched where it emerges from the great sacrosiatic foramen and lies on the bony edge of the notch. A tingling sensation or

"shock" will be felt by the patient running down to the foot and toes and the hamstrings as well as the muscles of the calf will be seen to twitch. Twenty cc. of 2 per cent novocaine are injected into the nerve at this point in the case of the adult male, and the needle is withdrawn.

The small sciatic nerve (posterior cutaneous nerve of the thigh) lies on the great sciatic nerve and is blocked with it.

ANALYSIS

Fifty-one patients were operated upon using the anesthesia techniques described. In the brachial plexus block series there were three groups: (1) *Eight upper arm cases*—four reductions of fractured humerus, two reductions of dislocated shoulder, one wound excision and reduction of compound fracture dislocation of elbow, and one wound excision and removal of foreign body; (2) *Eight forearm and wrist cases*—two reductions of fractured radius and ulna, two reductions of fractured radius (one a Colles' fracture), one wound excision and reduction of compound dislocation of radiocarpal joint with suture of ulnar nerve, two wound excisions and suture of flexor tendons and median and ulnar nerves after lacerations of front of wrist, and one amputation through junction of lower and middle one-thirds of forearm; (3) *Fifteen hand cases*—two amputations through middle, ring, and little fingers, (1) amputation through index finger, wound excision and reduction of compound fracture of terminal phalanges of middle and ring fingers, three wound excisions and reductions of compound fractures of phalanges, one amputation of thumb through proximal phalanx, one amputation through metacarpal bones of little and ring fingers and suture of flexor profundus and extensor tendons to middle finger and extensor tendon to index finger, one wound excision and reduction of compound dislocation of interphalangeal joint of thumb, one wound excision with reduction of compound fracture of proximal phalanx of thumb and suture of flexor

longus pollices and extensor longus pollices tendons, one wound excision and suture of flexor profundus tendon to the middle finger at the head of the metacarpal bone, one wound excision and suture of extensor tendons to index, middle, ring and little fingers on back of hand, one wound excision and closure of extensive lacerated wound of palm of hand and fingers, one incision and drainage of abscess on back of hand, and one incision and drainage of suppurative tenosynovitis of flexor sheath of ring finger and abscess of midpalmar space. In this series there were twenty-six males and five females, the ages varying from seven and one-half to seventy-five years.

In the sciatic block series there were seventeen reductions of fracture dislocations of the ankle, five showing marked, nine moderate, and three slight displacement. There were also four reductions of fractured tibia and fibula, two wound excisions and reduction of compound fractures of tibia and fibula (sciatic block combined with long saphenous nerve block), and one wound excision and reduction of compound fracture dislocation of ankle and reduction of fractured tarsal scaphoid, cuboid, and three cuneiform bones. In this series there were twenty-two males and four females, the ages varying from twelve to sixty-one years.

The only organic complications that resulted in the brachial plexus block series were localized gangrene of fingers in two cases, of skin of dorsum of hand in one case, and osteomyelitis of ring finger in the case of suppurative tenosynovitis. These all occurred in the hand group and it is believed that they could not be attributed fairly to the method of anesthesia used.

In the case of removal of foreign body from the left upper arm the patient complained shortly after the operation that he could not move any part of his left upper extremity. He was seen by Dr. F. H. McKay (Dept. of Neurology) who found "all sensations present in the left

upper extremity with complete motor loss in hand, wrist and forearm, the only exception being a flicker of movement in thumb flexion." He suggested that "an organic basis due to compression from a very tight tourniquet (applied before admission to check bleeding from the left basilic vein) might be held responsible but that nevertheless a large functional (suggestive) element must be present." All muscles of the left upper extremity responded well to Faradism and there was no reaction of degeneration. Function quickly returned to this patient and within months he was working full time again. This was the only case to show motor weakness after operation, and in view of the above findings it seems unlikely that the nerve injection could be held responsible.

In the sciatic block series there was one case of osteochondritis dissecans of the ankle which gave an excellent final result after removal of the loose fragment of bone and cartilage. Another case of fracture dislocation of the ankle suffered re-dislocation due to too early unsupported weight bearing. This patient, a luetic, had a fair final result after reconstruction of the ankle joint. Suppurative arthritis occurred in a case of simple fracture dislocation of the ankle. The reason for this complication was unknown and a fair final result was achieved after ankylosis of the joint. In a case of spiral fracture of the tibia and fibula gangrene of the lower leg and foot occurred postoperatively necessitating amputation seven inches below the knee. The gangrene here was attributed to traumatic spasm of the popliteal artery and its collaterals. It is not believed that any of these complications could with fairness be attributed to the nerve block.

As regards the degree of anesthesia obtained, it was complete in all but five cases of the *Brachial* series. One case of the *Forearm* and wrist group, an eighteen-year old patient, was a poor subject for any anesthesia other than general, and despite heavy sedation he was uncooperative from the beginning. In the other four cases the

anesthesia began to wear off toward the end of the operation and skin closure was performed painlessly under novocaine field block. This unexpectedly early wearing off of the anesthesia occurred without explanation in these four cases, but the situation by that time lent itself well to control by a simple field block. Usually the anesthesia persists for much longer than one hour and in one case of the *Hand* group perfect anesthesia was present throughout the whole of a four and one-half hour operation.

In the *Sciatic* block cases, slight complaints were registered in 5 cases, all during the manipulation of the fractured bone ends into position. As soon as the manipulation had ceased there was no further complaint. This leads one to suspect that the cause of the complaints might well be

the feeling of crepitus which, though unpleasant, is not painful, is felt by bone conduction and thus is not influenced by the block. It is probable that heavier sedation in these cases would have completely eliminated the slight complaints noted.

SUMMARY

A description is given of a successful technic for the use of novocaine block of the brachial plexus and the sciatic nerve in the regional anesthesia of the extremities, and the advantages of this form of anesthesia in emergency surgery are emphasized. A brief analysis is given of a series of thirty-one brachial plexus blocks and twenty-six sciatic nerve blocks used in this way.



PILONIDAL CYSTS

TREATMENT BY MARSUPIALIZATION OPERATION

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PILONIDAL cysts or cyst teratomas, as they are also called, are not unusual in private practice; however, they offered a major problem in military hospitals. There was the question as to whether they should be handled conservatively, or should be operated upon with the object of curing the condition, and just what type of operation should be done. The number of sick days had to be considered with the resultant temporary loss of this man to the service, together with possibility of recurrence of this condition following treatment.

Numerous young recruits would turn in for treatment before they had finished their preliminary training, others shortly thereafter. Many had sustained a slight injury that would result in a flare-up of these lesions. Some would date the beginning of their complaints to an injury received on the obstacle course or in a physical conditioning class. Later in their military career the injury was said to have been received while riding in a small boat in a rough sea, or while riding in some mechanized equipment over a rough terrain. Occasionally, an actual fall would be remembered. The frequent association of the complaint with mechanized equipment lead an author to refer to the condition as "Jeep Disease."¹

The pathological condition was present and the trauma only made it apparent. The injury was only the exciting factor. Some few cases give no history of injury.

It is rather surprising that pilonidal cysts were not observed or at least recorded in the literature until 1867 when Warren² first mentioned them. However, he did not offer any ideas as to their origin. Nothing

appeared in regard to this possible etiology until 1882 when Lannelongue's³ article appeared which advanced the theory of this possible origin from ectodermal invaginations. Five years later Tourneaux and Herrmann⁴ suggested that persisting vestiges of the neural canal might be their origin. Numerous articles have been written supporting one theory or the other. In 1934, Stone⁵ wrote an article in which he suggested that they might arise from a vestigial structure analogous to Preen's gland of birds. Fox⁶, in 1935, in his work in embryology, gave support to the invagination theory and he concluded that this took place between the third and fourth months from cells destined to form hair and glands. There is little to support Stone's⁵ theory; and the belief that it is due to invagination of the ectodermal layer is concurred in by most authors, and seems to be the most plausible in the light of experience with newer methods of surgery. Pilonidal cysts are definitely congenital in origin.

The lesions are seen most often in the sacrococcygeal region as manifested on the skin by a small sinus or sinuses, which may or may not be in the mid-line. One can get little idea of the extent or direction of the cyst and its tracts usually from the external appearance. They are subject to periods of more or less acute inflammation with increased annoyance to the patient. Often several hairs can be seen protruding from the sinus. Actual abscess is sometimes formed. Often the chronic watery drainage from the area is the only reason for the patient to seek surgical relief. In the military hospitals abscess

formation is the more frequent reason for treatment.

The incidence of pilonidal cyst is fairly high. In the Navy there were more sick days from this condition in 1940 than for either hernia or syphilis.¹⁰ Some pediatricians report that about one baby out of ten has this lesion present. It appears a little more common in the male than in the female.

The treatment can be divided into conservative and radical. The conservative is instituted with the idea not of curing the condition but only in getting the patient in condition to return to ordinary activity. This can be accomplished by simple institution of drainage usually by enlarging the sinus opening and application of wet heat. This was often done in the case of men in the armed services whose duties could not spare them for a long period.

More radical surgical procedures are necessary in effecting a cure. All operations can be included under three general headings: the closed type, the open type and the partially closed type. In order to do the closed type successfully it is necessary to excise all the cyst and its tracts, kill all dead space and be reasonably sure the operative field is dry and sterile, or nearly so. More often a little serum accumulates, plus a low grade infection and the entire area of operation opens up. I know of no way to be sure the area is sterile after dirty material has been excised. The closed method may get a patient well perhaps a little sooner than the other types of operation, but often there is disappointment; the wound opens up and there is a very long period of dressings.

Even wounds that for a time appear to heal after a lapse of several months may open and drain. Twenty-five per cent⁷ of patients with closed operations who show later drainage is a conservative figure⁸ in comparing reports, for according to some the figure is as high as 50 per cent.¹

The operations are many and closures vary in the closed type. A preoperative régime has also been advocated with the

object of clearing up infection and bed position postoperatively has been emphasized to take pressure off the skin area.

The semi-closed procedure is far safer in the greater percentage of cases than the closed. In some instances the closed eventually results in the semi-closed. It is the method that many of us have employed for many years. The cyst is removed, the edges brought loosely together and drainage instituted. In both of these methods the dissection is usually wide, sutures are uncomfortable and the patient bedridden, and many hypodermic for sedation are required.

By marsupialization many of these disadvantages are overcome. The wound is open, the patient is comfortable, rarely requiring any postoperative sedation, he is ambulatory and requires only a few days in the hospital. The operative area is not distorted by wide dissections nor is it tense from many sutures.

Buie⁹ first mentions the marsupialization operation in 1937 but very few articles have appeared in the literature about it. He cites¹ the accomplishments by this method to be: (1) The size of the wound is reduced and there is no necessity for sacrificing much tissue; (2) after healing a complete and adequate amount of tissue is left to pad the sacrococcygeal region; (3) recurrence does not follow when the operation is first performed for the condition; (4) the duration of the period from operation to healing is satisfactory; (5) no unusual preoperative preparation is required; (6) patients are hospitalized for only a few days; (7) no strenuous management, such as "locking the bowels," complete rest, special diet, etc., is needed; and (8) postoperative discomfort is negligible.

The anesthetic of choice is a low spinal. Local might be used if we know for sure the cyst to be small, but there is no way to be sure.

The operation of marsupialization preserves a portion of the wall along with the base of the cyst and utilizes it in the

closure, the skin edges being sutured loosely to the wall. This membrane will possess all the histological structure of the skin itself even if it has been modified or destroyed by inflammation. An abundance of scar tissue has been replaced and it will become just as efficient in the process of healing.

The technic of marsupialization is accomplished by inserting a probe or groove director into the opening and splitting the skin along its course. Multiple sinuses are treated in like manner. The overhanging edges are cut away along with a portion of the lateral wall of the cyst or sinuses. The remaining cyst and sinus are cleaned of hair and other material with gauze. It is nearly always possible to fit the skin edges to the adjacent walls of the cyst and they can be sutured to the edges of the remaining cyst wall. A plain catgut suture in lock-stitch arrangement is best used. This also controls nicely any bleeding from the edges. We might think of this operation as "unroofing" the cyst.

Should any small tracts be missed at the time of operation it has been my experience that that particular portion will become inflamed and painful and with the use of a little local anesthetic this portion can be unroofed in the dressing room or office and no sutures are required. This remaining portion will be evident on the second or third day postoperatively.

Recently I have had a series of thirty-seven patients whom I operated upon by the marsupialization technic. The cysts ranged from very small to very large. In only two was a tract missed and they were handled as outlined above. Low spinal anesthesia was used in all. No postoperative sedation was required except for those who had very large cysts. Patients were allowed and encouraged to be up the following day and sitz-baths instituted. The average patient could have left the hospital the third postoperative day. The

average wound was completely healed in three weeks. The largest wound was healed in six weeks. This patient, by the way, had been seen at one of the large hospitals in the west coast and had been told that the wound would take six months to heal. The cyst extended even down on the thigh. The patient who stayed in the hospital the longest in my service was one in whom primary closure was attempted only to open and drain. This wound required dressing for over three months and was slow in granulating. Had marsupialization been done, I believe he would have been healed in as many weeks.

Postoperative care, as mentioned, consists of sitz-baths, small dressings and the handling of excess granulations. The dressings are rarely very soiled.

Marsupialization offers the greatest comfort to the patient, requires fewer hospital days, and in my opinion, offers the greatest hope for cure. Although it is hard to judge the merits of a procedure from a small series of cases, this method of treatment has many distinct advantages and at the present time is the greatest advance in curing this condition.

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USE OF TRANSVERSUS ABDOMINIS IN REPAIR OF INDIRECT INGUINAL HERNIA

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THE two objectives of any hernial repair are to cure the immediate hernia and prevent a recurrence.

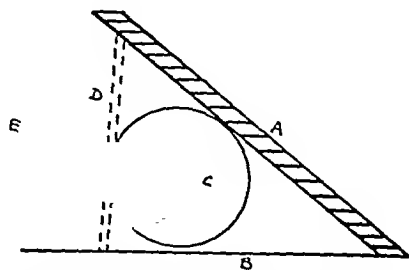


FIG. 1. The left inguinal region is represented diagrammatically. A represents the free margin of the aponeurosis of the transversus abdominis muscle; n represents the shelving margin of Poupart's ligament; c shows the internal abdominal ring, the margins of which are made up by the surrounding transversalis fascia; d indicates the deep epigastric vessel running beneath the transversalis fascia and bordering the inner margin of the ring. e indicates the cord structures emerging from the internal ring. The anatomical "v" described in the text is illustrated here with the internal abdominal ring appearing as a circle within the arms.

In young men with indirect hernias, the first of these objectives can often be accomplished by high ligation and resection of the hernial sac; the second by a proper repair of the dilated internal ring. The purpose of this article is to describe an operative technic for the accomplishment of this second objective, a technic in which the aponeurosis of the transversus abdominis is employed to reinforce the ring at the same time that its diameter is being reduced.

There are some points in anatomy, which are pertinent to this discussion and which should be reviewed before proceeding further. First, the "opening" in the transversalis fascia, known as the internal abdominal or internal inguinal ring is

bordered above by the free margin of the transversus abdominis and below by the shelving margin of Poupart's ligament. It lies somewhat as a circle within the arms of a horizontal "v," the open end of which points toward the midline of the body. (Fig. 1). Secondly, the transversus abdominis is aponeurotic where it is in contact with the ring. Anson and McVay^{1,2} and Morgan and Anson³ found it to be aponeurotic at that point in 97 per cent of cadavers they dissected. It has been found so in all of the patients operated upon for indirect inguinal hernia at this hospital over a sixteen-month period where its anatomy has been particularly checked. The third point is that the transversus is on almost the same deep plane of the abdominal wall as the transversalis fascia and where it is aponeurotic it is especially close in its relation to that fascia. On the other hand, the internal oblique muscle is definitely on a more superficial plane and is not aponeurotic where it passes the internal ring. The fourth point is that the deep epigastric vessels running underneath the transversalis fascia border the inner lower edge of the ring, medial to the place where the cord structures emerge; therefore, a repair of the transversalis fascia medial to the emerging cord directed towards narrowing down the internal ring carries with it the danger of damaging these vessels and causing hemorrhage or infiltration of blood into the tissues, which would interfere with the healing process.

OPERATIVE TECHNIC

At operation, after the redundant sac has been severed and its closed stump dropped back through the dilated internal

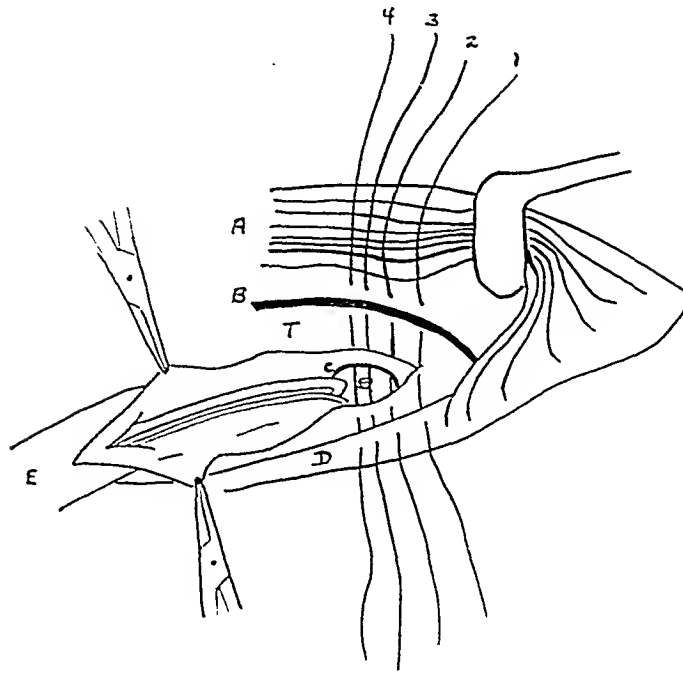


FIG. 2. This semi-diagrammatic drawing of the left inguinal region illustrates the placing of the sutures to effect the closure described in the text. A shows the retracted muscle fibers of the internal oblique. B is the aponeurosis of the transversus abdominis. The sutures represented by 1, 2, 3 and 4 enter the margin of the aponeurosis of the transversus abdominis and course under T, the transversalis fascia, to emerge through the upper edge of the internal abdominal ring C. Across the ring, they pierce the lower margin and continue under the transversalis fascia again to emerge through D, the shelving margin of Poupart's ligament. E represents the opened cord with the cord structures exposed. Within the circle of the internal abdominal ring, the tied off stump of a hernial sac is illustrated.

ring, repair plus reinforcement of the ring is accomplished in the following way: The shelving edge of the aponeurosis of the transversus abdominis is first identified and exposed. Good retraction of the internal oblique is necessary to accomplish this, and at times, very occasionally, in strongly muscled individuals, the arching edge of this muscle must be incised in order to displace it properly. Next, the dissection must be carried through cremaster muscle fibers and areolar tissue, which may veil the free edge of the aponeurosis of the deeper transversus abdominis muscle. After this edge has been identified and cleared, the shelving edge of Poupart's ligament is similarly exposed. When satisfactory exposure of both these structures has been obtained, one begins at the outermost part of the ring and places interrupted sutures. (Fig.

2.) Each suture passes through the following structures: (1) The edge of the aponeurosis of the transversus abdominis; (2) the transversalis fascia forming the upper margin of the internal abdominal ring; (3) the transversalis fascia forming the lower margin of the internal abdominal ring, and finally (4) the shelving margin of Poupart's ligament. The manner of placing these sutures may vary from case to case. The first bite may be taken from above or again from below or the suture may be started in through Poupart's ligament continued upward through its shelving margin and after the desired structures are included, out again through Poupart's ligament to be tied on the surface of that structure, the essential thing being that the four structures listed above be picked up by each stitch. After a sufficient number of such sutures are placed (two to

four usually), they are tied in the order of their placing and the result is that the internal ring is narrowed down till it fits snugly about the emerging cord structures. At the same time, the transversus aponeurosis and Poupart's ligament are approximated and form a closed door over the previously opened portion of the internal abdominal ring. These two fibrous structures are now even more intimately bound to the underlying transversalis fascia than they were before since this structure was included in the same sutures and has been brought up tightly against their under surface. It is also worthy to note that fascia has been sewed to fascia fulfilling what is held by some to be a requirement for good healing. Consider also the reinforcement which has been accomplished; it is immediate and intimate and not a plane or two removed from the place being reinforced. In this latter point, the present technic differs from the classical technic of Ferguson, wherein the more superficial and more muscular internal oblique is used to reinforce the repaired internal ring. The potential or real "dead space" left between the repaired ring and the transposed internal oblique in the Ferguson repair does not remain after the operation herein described has been completed.

SUMMARY

Four points in the anatomy of the inguinal region are brought out; first, the close relationship between the internal ring and the free edge of the transversus abdominis above and with Poupart's ligament below; second, the fact that the transversus abdominis is aponeurotic at this point; third, that the transversus abdominis aponeurosis and the transversalis fascia are almost on planes of identical depth in the makeup of the abdominal wall; fourth, the dangerous position of the deep epigastric vessels medial to the inner margin of the internal abdominal ring.

Considering these anatomical facts, a technic has been devised in which the aponeurosis of the transversus abdominis is sewed down to the shelving margin of Poupart's ligament, the ring margins being included in the sutures for the closure of the dilated internal ring found in association with indirect inguinal hernias. The intimate reinforcement given by this technic, and the lack of "dead space" following its use is emphasized.

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ULTRAVIOLET BLOOD IRRADIATION IN BILIARY DISEASE

KNOTT METHOD

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ONE of the most frequent and perplexing problems confronting the average physician and surgeon, whether in general practice, internal medicine or surgery, is disease of the biliary tract. Drainage is of primary importance in the resolution of all inflammatory and infectious diseases, and this is equally important in disease of the biliary tract. As long as we have free and proper drainage of the biliary tree, we do not have biliary disease. We are so accustomed to speaking of gallbladder disease that we are prone to forget that the obstruction of the biliary ducts due to swelling and inflammatory reaction, obstructing drainage and function of the gallbladder is the primary cause of gallbladder disease. So, in considering gallbladder disease, we must first emphasize that this is a disease of the biliary tract in which the most important part of this disturbance is obstruction to free bile drainage.

In using ultraviolet blood irradiation therapy (Knott method) in acute and chronic inflammatory diseases, we early noticed the marked and rapid reduction in swelling, pressure and inflammation; this was so marked that we began treating non-malignant disease of the biliary tract in the hope that this marked reduction in swelling, inflammation and pressure would allow biliary drainage and facilitate recovery of these patients. To date, we have treated 383 patients with all types of non-malignant biliary disease in which the results have been so interesting that we believe they are worth reporting. These cases have been classified as follows: (1) Acute, very severe, patients almost moribund, three; (2) acute, very severe, five; (3) chronic, without stones, 264; (4)

chronic, with stones, fifty-six; (5) chronic cholangitis and hepatitis, gallbladder previously removed, fifty-five.

Acute Very Severe—Patients Moribund. Two patients were seen in extremely critical condition. One patient was seventy-eight years of age; the other, eighty years of age. The white blood count was 30,000 and 35,000, respectively; both were semicomatous, markedly jaundiced, with rapid pulse and a large, rigid, tender mass in the upper right quadrant indicative of definitely acute, severe cholecystitis and biliary disease. Both patients had been under treatment for more than a month without improvement and were sent to the hospital to die. With ultraviolet blood irradiation therapy, both of these patients responded promptly and rapidly. In three and four days, respectively, both were taking nourishment, the swelling and mass in the upper right quadrant subsided markedly, the white count came down and the general condition improved rapidly. Both were discharged from the hospital after fourteen and eighteen days, respectively, without surgery. Both patients have been followed for more than a year; neither has had a recurrence and both have been feeling very well. Functional gallbladder x-rays several months later revealed moderate concentration of dye in the gallbladder with fairly good function.

One other case was almost identical with these two except that this patient had a decompensated heart along with biliary findings and was in a moribund condition. Her progress after ultraviolet blood irradiation therapy was slower, but there was very marked improvement. She has now been observed for more than a

year and is up and about in a very normal condition for a person of her age.

Acute Severe Cases. Five patients were seen with acute, severe cholecystitis with increased leukocyte count, temperature, mass in the upper right quadrant very tender, and varying degrees of jaundice. All of these patients showed marked relief from ultraviolet blood irradiation therapy; relief from pain, swelling, and tenderness was very prompt within twenty-four to forty-eight hours; the temperature went down rapidly and the swelling reduced markedly in two to three days.

Four of these patients have not been operated on and have had complete relief from symptoms for a period of from four months to one-and-a-half years.

The fifth patient proved to have stones in the gallbladder and was subsequently operated on with complete relief of symptoms. In this case, the patient's operative condition was made very safe and easy by the preoperative ultraviolet blood irradiation therapy, and when operated on the patient was in good surgical condition.

Biliary Disease, Chronic, without Stones. This is a large series of cases of chronic biliary disease without stones. All of these cases were typical cases of chronic biliary disease in which the history and physical findings were typical. Careful study of each case was made to determine the diagnosis; all the patients had functional gallbladder x-rays, gastrointestinal x-rays, gastric analysis, serology, and any other examination believed necessary to determine the diagnosis and differential diagnosis. These patients had all been under treatment for a period of time, varying from months to years, some by others and some by myself. All of them had typical symptoms of recurrent attacks of jaundice of varying degrees, indigestion after meals, excessive gas, recurrent attacks of pain in the upper right quadrant and epigastrium, and many had pain referred to the subscapular region on the right side. All except twelve of this group received marked relief of symptoms and have been

observed for a period of four months to one and a half years following treatment. The relief in this group of patients has been very encouraging, and these patients have been very grateful for their relief. Dietary and medical management were continued in these cases following and along with ultraviolet blood irradiation therapy. The important point is that the ultraviolet blood irradiation therapy seemed to reduce swelling and congestion in the biliary tract, promoting bile drainage, and was just another important step in the treatment of these patients. None of these patients has been operated on.

There are three interesting cases, however, in which the gallbladder had previously been drained and not removed; two patients had stones, one did not have stones. None of these patients had been operated on by me. All had gone for several years with marked recurrence of their cholecystitis. All three have obtained practically complete relief of symptoms and functional gallbladder x-rays show quite normally functioning gallbladders, which previous to treatment had shown no shadow or only a slight shadow.

Chronic with Stones. This is a group of chronic biliary disease with cholelithiasis in which forty-eight have been operated on. These patients were all prepared for surgery by preoperative ultraviolet blood irradiation therapy along with all usual preparation of these cases. It is important to emphasize that these patients were relieved of symptoms markedly by ultraviolet blood irradiation therapy and that their surgery was made much easier and safer. Comparing this group of surgical cases with similar patients operated upon over many years of time, I have been greatly impressed with the difference; postoperative ileus, pain and distention were much less and convalescence was markedly smoother than previously.

Chronic Cholangitis and Hepatitis, Gallbladder Previously Removed. This is a very interesting group of fifty-five cases

of biliary disease in which the gallbladder had previously been removed and who continued to have recurrent attacks of symptoms. These patients continued to have recurrent attacks of jaundice of varying degrees, indigestion after meals, gas, pain in the upper right quadrant and epigastrium, and many with pain in the subscapular region on the right side.

Forty-six of these were greatly relieved of symptoms and have been observed for from four months to one and a half years and have remained free of symptoms during this time; the others obtained moderate relief, but some of these had not continued treatment as suggested. Dietary and medical management were continued as previously in these cases. On all cases of chronic biliary disease, complete studies were made to determine the diagnosis and differential diagnosis: x-ray studies of the gastrointestinal tract, gastric analysis, blood study, and whatever other information seemed pertinent to prove the diagnosis in these cases.

PREOPERATIVE CONSIDERATIONS

Forty-eight cases were prepared for surgery by preoperative ultraviolet blood irradiation therapy; these were all cases in which the surgical attack was considered hazardous or serious, some extremely hazardous. In using this preoperative preparation, there has been very little postoperative ileus, distention and similar disturbances; very few have had to have intranasal stomach drainage, and the amount of intravenous fluids has been about half the amount used previously. These patients were able to take fluid by mouth very early, were able to turn and exercise without much difficulty and their feeling of well being was very marked. Postoperative complications, such as pulmonary involvement and phlebitis, have been very few. These observations have been carefully compared with similar patients operated upon over many years' time.

Two patients in this group died; both had gangrenous gallbladders. Both were

elderly people and their condition was practically hopeless.

POSTOPERATIVE CONSIDERATIONS

In cases requiring prompt and immediate surgery in which peritonitis is extensive and the patient is in a critical condition, ultraviolet blood irradiation therapy is extremely valuable. Treatment can be given very soon after surgery. In almost all cases, there is marked relief of cyanosis, distention, ileus and marked improvement in the patient's general condition. Intranasal stomach drainage is used very little and patients improve much more rapidly than a similar group operated upon over many years of time before. We believe definitely that recovery in many of these cases was due to the help received from ultraviolet blood irradiation therapy.

SUMMARY AND CONCLUSIONS

Ultraviolet blood irradiation has now been used for one and a half years, and after this time of observation some very important clinical observations stand out:

1. After treatment with ultraviolet blood irradiation, there seems to be a prompt and marked reduction of swelling and pressure, which seems to be particularly important in the treatment of diseases of the biliary tract.

2. In severe peritonitis with postoperative ileus, this is by far the most effective treatment I have ever used. There is marked increase in the tone of the intestinal tract, relief of severe reverse peristalsis, cyanosis and such symptoms to a marked degree. Extremely ill patients respond to this treatment that do not respond to any other.

3. In preoperative preparation of serious surgical cases, it is of great value. Patients withstand serious surgery with fewer complications, have less pain, require less intravenous fluids and recovery is hastened; pulmonary complications and phlebitis are markedly reduced and, when they occur, respond markedly to ultraviolet blood irradiation.

PHYSIOLOGY OF THE NOSE AND ITS RELATION TO PLASTIC SURGERY*

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THE primary purpose of the rhinologist is to restore a disturbed nose to normal function. In that "nor-

mal" result in side chain reactions that will serve to upset the physiology of the whole nasal chamber. Once the circle is begun



FIG. 1. A, old fracture of the nose, resulting in external deformity and internal dislocation of the septum. At the time of the nasal reconstruction the septum was relocated with an Asech forceps; B, following surgery and restoration of normal breathing space.

mal" presents such a wide latitude, the end result will be dependent on the material presented and the cleverness of the clinician.

Primarily, the nose functions as an air passage. The mucous membrane, the cilia, glands, turbinates and the sinuses have individual functions all coincidental with the passage of air. Nasal blockage may cause drying, interfere with drainage and

and especially if it becomes chronic, it may require more than merely eradication of the original causative factor to overcome the pathological condition.

Allergy, vasomotor rhinitis, trauma, tumors, congenital defects, either singly or in combination, may serve to disturb the individual's normal physiology. Conservative procedures should be first attempted before more radical surgical effort

* Presented in conjunction with colored surgical motion pictures at the Los Angeles County Medical Association, October, 1945, and at the Harbor Branch of the Los Angeles County Medical Association, February, 1946.



FIG. 2. A, congenital deformity. The long upper lateral cartilages in conjunction with a dropped tip created a ball-valve action causing bilateral intermittent blockage of breathing; B, reconstruction of the nose with internal adjustment resulted in both an improved cosmetic and physiologic picture.

is instituted. When surgery is the choice, the operator should possess a preconceived picture of the end result he hopes to obtain. Unfortunately, bulldozing a pathway within the nose with the scapel is not the answer. The aperture created by surgery must be physiologically correct or the patient may be worse. Function must be the guiding impetus of all incisions.

The pathway followed by inspired and expired air and the physiologic effects of pathologic change in the air passages have been well discussed by Proetz.¹⁵ With a knowledge of these concepts, the clinician must attempt to return the tissues to as near normal function as possible.

A bulging turbinate blocking the airway should be investigated for the presence of allergy or infection in the sinuses. If these measures fail, cauterization, electrocoagulation, submucous resection of the turbinates or injection may be employed.⁶

When the preceding deformity is present

in conjunction with a deviated septum blocking the nasal passage, or a flattened tip with depressed upper and lower lateral cartilages, the investigation becomes more complicated.

THE AIRWAY

Inspired air gathers moisture as it passes over the turbinates and warms close to body temperature. In performing this duty, the nose contributes almost a liter of water in a day and a night. This round the clock function of the nose requires about seventy calories.

Due to electrostatic charges within the nose and the moisture present, the passageway is self-cleansing of particular matter. A constricted opening, wide scars due to incisions, senecia or spurs, all may act to create eddy currents and upset the normal cleansing processes that occur within the nasal vault.

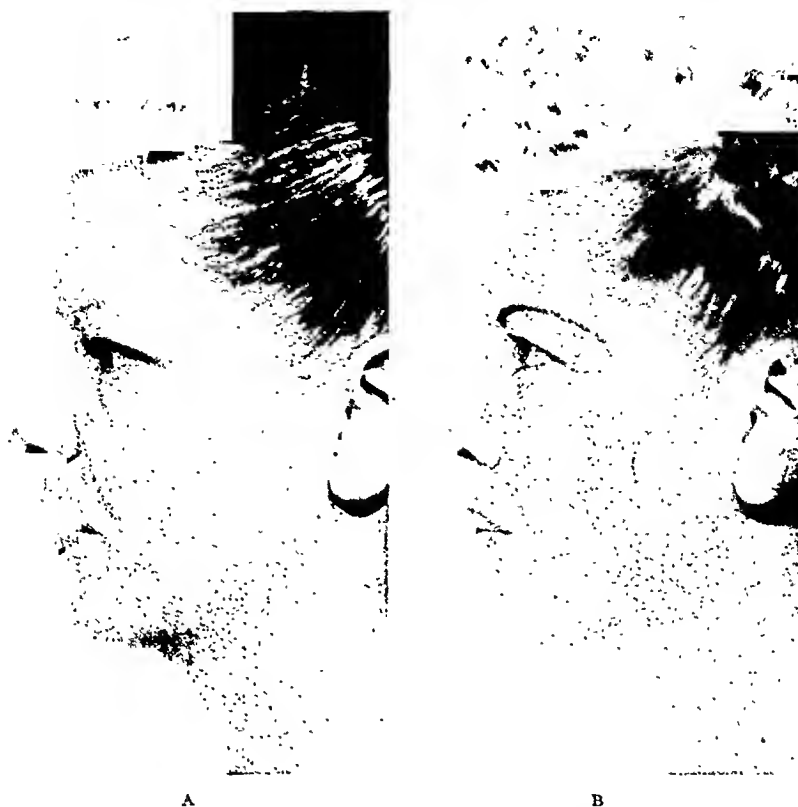


FIG. 3. A, dislocated and fractured septum; complete curvature of the septum toward the right and total blockage of breathing. The early fracture had resulted in deformity which required cosmetic correction, as well as restoration of the physiologic air passage. B, following rhino-osteoplasty and reconstruction of the septum as depicted in the drawings.

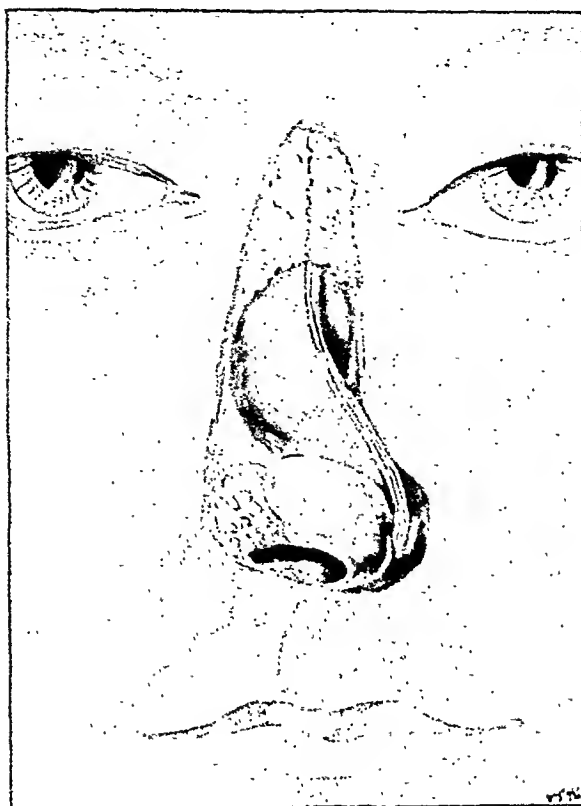
If the disturbance to the tissue within the nose be of major consequence, the mucosa, the cilia and the glands cannot perform their function, so that drying occurs. Over a long period of time, excessive drying will incapacitate the cilia, causing a change in the epithelial nature from ciliated columnar to squamous cells. Such a metamorphosis results in crusting and discomfort to the patient.

The narrowest portion of the nasal

passage exists approximately $1\frac{1}{2}$ cm. posterior to the alar rim. Its boundaries are formed by the septum medially, the fold of tissue between the upper and lower lateral cartilages above and the floor of the maxilla below. Interference with this opening may result in a condition ranging from complete obstruction to partial closure with a ball-valve action.

The longest incision in a rhino-osteoplastic operation lies in this area. It com-

FIG. 4. Author's procedures in reconstructing a twisted anterior septum. A, in such cases a submucous resection will serve no purpose and is actually contraindicated. The twist involves cartilaginous septum which includes the upper lateral cartilages. The latter are severed from the septum intranasally and after the required amount is resected the septum is reconstructed. B, the nose has been diagrammatically bisected to demonstrate the intranasal operation. Mucous membrane on the convex side is dissected away from the cartilaginous septum. A modified hyperbolic incision through the cartilage to the opposite mucous membrane is made from the dorsum of the nose downward to the nasal spine. Approximately a millimeter anteriorly, a similar parallel incision is made allowing the curved sliver of cartilage to be resected. Should the convexity be acute a similar procedure is carried out more anteriorly. C, the mucous membrane is then laid back against the cartilage and several staggered sutures (No. 000 black silk) are taken through the mucous membrane, cartilage and the opposite mucous membrane. The curvature of the septum is thus corrected and normal physiologic function of the nose restored.



A



B



C

FIG. 4.
For caption see page 240.

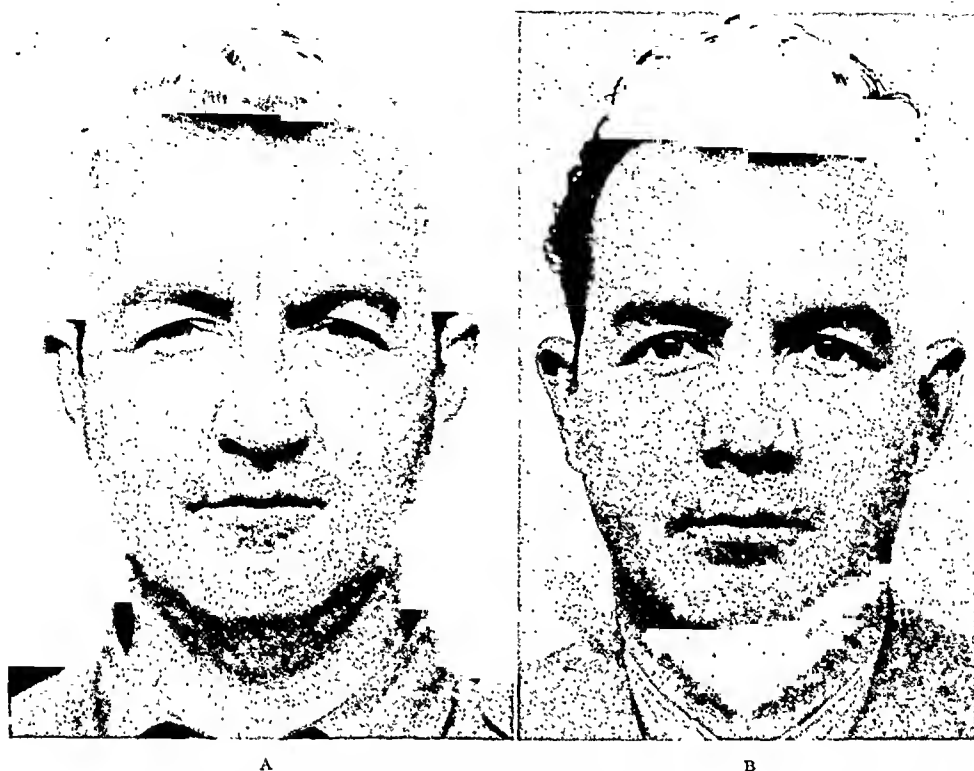


FIG. 5. A, flattened nose resulting from a complete removal of the septum many years ago; B, restorative surgery necessitated reconstruction of the nose and a cartilage plate grafted between the empty mucous membrane flaps, extending within the columella from the tip to the nasal spine and backward to the vomer.

mences in the lowermost lateral portion between the upper and lower lateral cartilages, is brought forward and upward to the tip of the septum, then curved and brought downward to separate the septum from the columella. Unless the surgeon is always cognizant of the physiologic and mechanical importance of this aperture, an annular scar may occur with resulting obstruction.

If the scars within the nose be wide or overriding, they will serve as dams against the normal ciliary pathway. Not only will the effected side of the nose suffer, but an asymmetry of nasal ventilation will occur with the opposite side taking over most of the burden, thus resulting in excessive drying of the mucosal walls.

A scar contracture of this hiatus causes a stream of air to be inspired through a small opening under increased pressure which results in eddy currents that upset the normal humidification and cleansing processes of the nose.

CLINICAL FINDINGS

In reviewing the last 500 consecutive cases who have presented themselves for rhino-osteoplasty, 22 per cent present symptoms and/or a history of partial nasal blockage. Allergic rhinitis, deviation of the septum or a combination of both are the main causative factors in that order.

The plastic surgeon must be prepared to evaluate physiologic disturbance to the internal nasal passage. A patient with an external nasal deformity who also suffers with nasal blockage, "sinus headache," post-nasal drip, "frequent colds," should be handled as a complete entity. A recognition of physiologic disturbance and consultation with an otolaryngologist prior to nasal reconstruction will result in a much happier patient and surgeon.

The discovery of a guilty allergen, the removal of polyps or spurs, or a thorough submucous resection when required may aid in restoring the normal physiology.¹⁻⁴



FIG. 6. A, fracture of the nose in conjunction with congenital deformity; B, the cosmetic and physiologic improvement stimulated the patient to have dermatologic consultation for eradication of a long standing case of acne.

Often the rhino-osteoplasty with a straightening of the septum and reconstruction of the upper and lower lateral cartilages may do much to overcome mechanical difficulties of the airway.

The surgeon must attempt to judge the normal for each individual patient. When disease is chronic, when tissue has become thickened and when fibrosis has invaded normal ciliated areas, the surgeon must employ those procedures with occasional modifications that will restore the nasal passage to a functional airway without making the patient worse. Such procedures that may be applicable in one case may be entirely wrong in another, and the surgeon's guide should be a plan with his eye focused on the end result.¹⁸

THE SEPTUM

We have previously discussed the importance of a thorough submucous resection when required.¹⁰ Should the deviation

be associated with a nasal deformity, the former may be accomplished three or four months prior to the latter. In occasional cases, the submucous resection may be done afterward; it is no longer our policy to do both operations together.

Should the septum be dislocated from the vomer groove, it may be replaced with an Asch forceps at the time of rhino-osteoplasty.⁹ This is accomplished with little difficulty after the septum has been detached from its anterior and inferior moorings. (Figs. 1 to 7.)

Due to previous injury, the end of the septum may terminate in an abrupt curve. Such a defect cannot be overcome by a submucous resection and may cause a cosmetic deformity of the nose, as well as mechanical blockage to the airway. Several methods of conquering such a problem have been suggested.^{3, 13, 16, 17} After deflecting the mucous membrane on the convex curve of the deformed septum, a thin



FIG. 7. A, congenital deformity associated with an early fracture: dropped tip, long upper lateral cartilages and dislocated septum had interfered with normal ventilation; B, six weeks following rhino-osteoplasty and relocation of the septum.

hyperbolic sliver of cartilage, extending from the dorsum down to the nasal spine, is resected. Where required, a second piece of cartilage may be removed more anteriorly. The mucous membrane is replaced and staggered sutures taken between the separated sections of cartilaginous septum. (Figs. 3 and 4.)

UPPER LATERAL CARTILAGES

In cases with a flattened cartilaginous bridge, or a large nose with excessively long upper lateral cartilages, the nasal passage may be partially blocked, producing a ball-valve action with inspiration. The least amount of mucus, which is more apt to be present in these cases, due to lack of aeration, will further exaggerate the picture. Such patients present an effort at inspiration, the alar rims flare outward, while the alar grooves deepen appreciably. (Figs. 2 to 6.)

Such deformities may be corrected if they are properly evaluated. A saddle deformity of the lower dorsum may re-

quire a cartilage graft or the upper lateral cartilages themselves may be so fashioned as to overcome the defect.¹¹ When the tip is overhanging, the necessary amount of cartilaginous septum and upper lateral cartilages are resected.

Meticulous care should be entertained in suturing the lining of the upper lateral cartilage to the lower lateral cartilage on both sides. A more exact approximation results in less granulation tissue and a finer scar. The latter is especially important from a physiologic standpoint to avoid any barriers to ciliary pathways. Careful suturing will aid in avoiding the ball-valve action of the lateral walls.

LOWER LATERAL CARTILAGES

The surgical procedure in reconstructing the nasal tip that results in a pleasing contour without physiologic interference to the nasal vestibule has previously been described.⁶ Pinching or collapse of the lower lateral cartilages may be prevented if these members are carefully

undermined and allowed to slide to their new position. Careful suturing of the lining will aid both in the cosmetic and physiologic reconstruction.

The columella, consisting of the medial crura of the lower lateral cartilages may serve as a causative factor in airway blockage. This is especially true in cases of fracture and septal dislocation. In conjunction with septal relocation, reconstruction of the medial crura of the lower lateral cartilages is often necessary.

A cartilage graft within the columella or at the columellar-philtrum juncture may be demanded. Upper or lower lateral cartilages, septal cartilage, autogenous rib cartilage or necrocartilage may be employed.^{5,8,14} Time should be allotted to sculpture the cartilage so as to obtain a more pleasing cosmetic result. (Fig. 5.)

Rather than utilize a single "orthopedic" suture, we realign the septum to the columella with a series of sutures on either side. Again, it is our belief that the time necessary for such a procedure is balanced by the advantages gained.

NASAL LINING

Though this paper does not primarily deal with loss of nasal tissue, the problem is often presented. When nasal lining is required in conjunction with a compound pedicle, we usually employ a split skin graft.^{2,7} The forehead flap, the sickle flap, a pedicle from the arm or other procedures may be utilized as required.¹²

Atresia of the nostril will necessitate excision of scar tissue and the prepared cavity made sufficiently large to compensate for contracture. For reconstruction of the nasal lining, either oral mucous membrane or a split skin graft may be utilized.

The graft may be sewn or cemented around a dental stent that has been modelled to fit the defect.¹⁹ The stent is allowed to remain in place eight to ten days. After its removal, the area is cleansed and the stent reapplied. Following this, a hollow obdurator is used intermittently for many weeks to prevent contracture. The restoration of an airway will aid the

nasal vault to carry on its physiologic duties.

SUMMARY

1. The plastic surgeon must evaluate and correct physiologic defects within the nose.
2. The septum, the turbinates, the cartilages of the nose and the nasal lining must be considered as a physiologic entity.
3. Cartilage grafts, bone grafts, mucous membrane or split skin grafts may be utilized when required.

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HEMOLYTIC STREPTOCOCCUS IN WOUNDS OF RABBITS*

ACTION OF 5-NITRO-2-FURALDEHYDE SEMICARBAZONE

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IN a series of publications^{1,2,3} the effects of various disinfectants and chemotherapeutic agents upon hemolytic streptococcus in artificial wounds of rabbits were reported. It was shown that the antibiotics, penicillin, tyrothricin, and streptothricin, exerted definite anti-streptococcal activity *in vivo*. Sulfonamides proved to be largely ineffective. Recently, Dodd and Stillman⁴ reported on the bacteriostatic activity of some simple furan derivatives. These authors found that certain nitro-furan compounds inhibited *in vitro* the growth of bacteria or exerted bactericidal effects, even when the drugs were used in relatively low concentration. Of the compounds studied, 5-nitro-2-furaldehyde semicarbazone proved to be most promising for possible therapeutic application. It seemed of interest, therefore, to determine whether or not this drug is also effective against hemolytic streptococcus in artificial wounds of rabbits. The results of these experiments are embodied in the ensuing report.

Material and Methods. The technic employed has been described in detail elsewhere.¹ Medium-sized rabbits were used. Artificial wounds, measuring approximately 1 cm. in diameter, were infected with a twenty-four-hour infusion broth culture of a group A beta hemolytic streptococcus. This strain proved to be sulfonamide-susceptible *in vitro*. The drug, 5-nitro-2-furaldehyde semicarbazone, was applied to the wounds either in powdered form (1 and 10 mg.) or in a washable base

in a concentration of 1:500. The formula of the base is as follows:

	Per Cent
Carbowax 1500.....	55
Carbowax 4000.....	20
Propylend glycol.....	25

The effects of these drugs upon the hemolytic streptococcus in the wound was determined by taking cultures of the wounds after treatment for various periods of time. Material from the wounds was seeded on 5 per cent human blood agar. The agar plates were then incubated for seventy-two hours at 37°C. and the approximate number of colonies of hemolytic streptococci was recorded.

Results. In all, 146 individual wounds infected with the hemolytic streptococcus were treated with 5-nitro-2-furaldehyde semicarbazone or served as untreated controls. The results were as follows: (1) In thirty-three out of thirty-four control wounds many hemolytic streptococci persisted during the observation period ranging from twenty-four to seventy-two hours. (2) In contrast, treatment of the wounds with the furan compound reduced the number of hemolytic streptococci in seventy-two out of 112 wounds. Ten mg. of the drug in powdered form was effective in thirty-one out of forty-one experiments and 1 mg. in eleven out of nineteen experiments. Furan, in amounts of 0.2 mg. in washable base, caused a reduction in the number of hemolytic streptococci in thirty out of fifty-two infected wounds. That prolonged treatment yielded better results is evidenced by the following ob-

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ervation: Reduction in the number of hemolytic streptococci after treatment for twenty-four hours occurred in only eight out of twenty-two experiments and after therapy for seventy-two hours in ten out of fourteen experiments.

Comment. It is well known that the *in vivo* activity of disinfectants does not always parallel that exerted under *in vitro* conditions. It is noteworthy, therefore, that the bacteriostatic activity of 5-nitro-2-furaldehyde semicarbazone demonstrated *in vitro* by Dodd and Stillman could be established also in experimentally infected wounds. It is worthy of note that, as shown previously, sulfanilamide and sulfathiazole, even in amounts of 100 mg. applied for twenty-four to forty-eight hours, failed to exert any significant effect under like experimental conditions. On the other hand, the antibiotics penicillin, tyrothricin and streptothricin caused a reduction in the number of streptococci in such infected wounds.

The selection of any antimicrobial agent to be used in the treatment of localized or systemic infections of man depends upon several factors, in particular upon its *in vivo* activity toward the respective microorganisms and its toxicity. That 5-nitro-2-furaldehyde semicarbazone is of limited toxicity and is effective in infections of man has been shown by Dodd, Hartmann and Ward⁵ as well as by Snyder, Kiehn, and Christophersen.⁶ Further experiments

and clinical observations are necessary to determine the merits of this compound as an antimicrobial agent for the treatment of localized and systemic infections of man.

SUMMARY

The compound,* 5-nitro-2-furaldehyde semicarbazone, in amounts of 0.2 mg. to 10 mg. (in powdered form and in a washable base) reduced the number of group A beta hemolytic streptococci in artificially infected wounds of rabbits in a substantial number of experiments.

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* The authors wish to express their appreciation to Dr. M. C. Dodd and the Eaton Laboratories for supplying the compound used in this investigation.



NEW OPERATION FOR DISLOCATED SEPTAL CARTILAGE*

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THE otolaryngologist is frequently confronted with the problem of correcting a nasal obstruction due to a septum and with an external nasal deformity, the same operative procedure is followed. This is so because the deformities

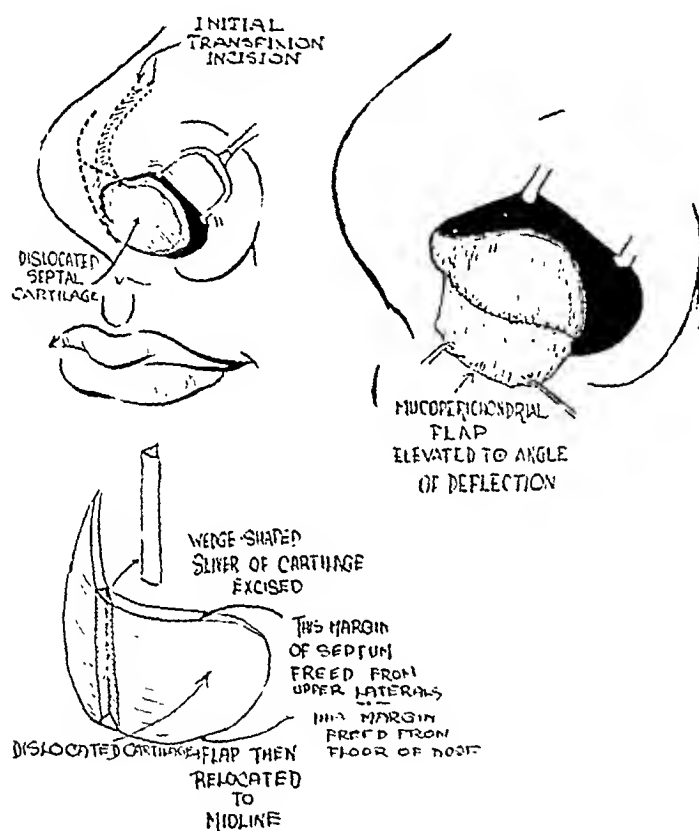


FIG. 1.

dislocated septal cartilage. This dislocation may be the only abnormality present, but it may be associated with an external nasal deformity. Usually the dislocated septal cartilage is just the anterior part of a generally deviated septum.

Regardless of whether the dislocated septal cartilage exists alone or whether it is associated with deflections of the bony

are merely varying degrees of derangement of the anatomical structures. The amount of distortion of cartilage and bone and the scarring and contracture of the surrounding soft parts regulate the degree to which the operative procedure is carried out. In this operation one secures permanently the septum in its mid-line position.

* Part of paper read before the American Otorhinologic Society for the Advancement for Plastic and Reconstructive Surgery, Inc., under the title "Rhinoplasty and Nasal Rhysiology" on November 11, 1944. Also read before the Section on Laryngology, Rhinology and Otology of the Medical Society of the County of Kings and Academy of Medicine of Brooklyn, on April 11, 1945, as part of paper titled "Rhinoplasty and the Submucous Resection as Aids Towards Improving Nasal Physiology with Presentation of a New Technic for Correcting the Dislocated and Obstructing Septal Cartilage Associated with and without External Nasal Deformity."

Before proceeding to the new operation here advocated, I wish to correct some erroneous concepts about the nasal septum. We are all familiar with the teaching that in performing a submucous resection one must leave intact enough of the septum to assure adequate support of the so-called dorsum of the nose. Occasionally, it is just this residual supporting segment of the septum which is the obstruction we are now seeking to correct. My personal studies in this direction have led me to the conclusion that the primary function of the septum is to help direct air currents within the nose. Contrary to the accepted belief, in my opinion, the septum contributes little support, if any, to the nasal bones and the upper lateral cartilages. It has only one supporting value of importance, and that is to the area of the tip. A saddle deformity may occur after some submucous resections. This results when the upper lateral cartilages end short of the distal end of the septum. In such exceptional cases the operator must preserve a prow-like projection of the septal cartilage to give support.

NEW OPERATIVE PROCEDURE

After adequate local anaesthesia, a rhinoplastic transfixion incision is made. (Fig. 1A.) When the dislocated cartilage is just displaced from the interspinous attachment and from the vomerine groove, and when its accompanying mucoperichondrium is not scarred and bound down in its abnormal position, and when the columella is still in the mid-line and the nasal frame-work is not deformed, the next procedure is simple. The deflected cartilage is exposed on one surface by elevating the mucoperichondrial flap, ventrally as far as its attachment to the upper lateral cartilages, caudad to the floor of the nose and posteriorly to the angle of deflection. (Fig. 1B.) If the cartilage is displaced transversely beyond the mid-line from one nostril to the other, it is then exposed beyond the angle of deflection and followed backward until undelected septum is reached. The exposed

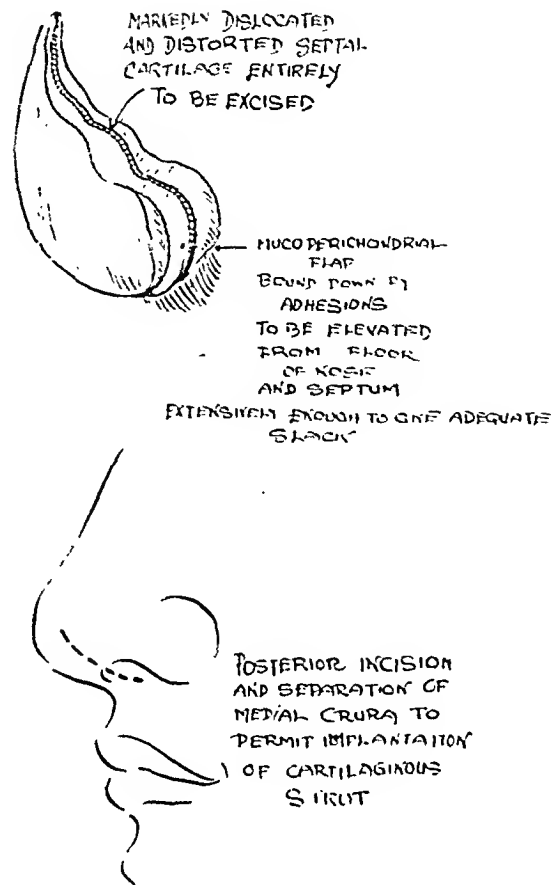


FIG. 2.

cartilage is then cut free, above from its attachment to the upper lateral cartilages, below from the floor of the nose, and behind from the remaining septum. As soon as the deflected cartilage is liberated from its attachments, it should be easily re-located into the mid-line and fixed into a bed prepared at the cephalad aspect of the columella. It may also be necessary to correct simple angulations or bowings within the fragment of deflected cartilage by cross hatching or removing wedge-shaped slivers of cartilage. (Fig. 1C.) Except for the rhinoplastic transfixion incision, the procedure presented so far has been that outlined by Safian* as the "Swinging Door Operation," more commonly known as the Metzenbaum technic.

If the septal cartilage is dislocated and crushed as well, and if it exists with nasal deformity, one still begins with the rhinoplastic transfixion incision. Next the nasal hump is removed and the upper lateral cartilages are completely freed from their

* Safian, Joseph. *Corrective Rhinoplastic Surgery*. Pp. 178-179.

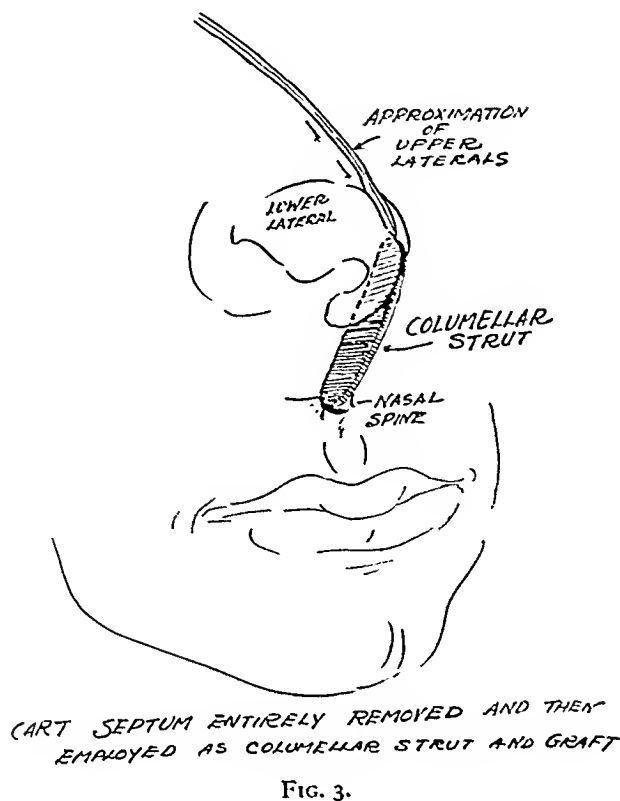


FIG. 3.



FIG. 4. A, dislocation of septal cartilage beyond alar rim; B, after correction.

septal attachments. The cartilage of the septum can thus be approached both from its anterior and its caudal aspects. The technic is then to expose one surface of the septal cartilage until undeflected septum is reached and then free this exposed cartilage at all its margins. One usually finds that as soon as the fragment of cartilage is liberated from its marginal attachments it is drawn into an unnatural position beyond the mid-line because of the scar contracture of the mucoperichondrium attached to the other surface of this cartilage fragment. It is in this instance that it is necessary to excise the *deflected cartilage entirely*. The excised piece of cartilage is placed aside, later to be used as a columellar strut and septal graft. The mucoperichondrial flaps are undermined both from the remaining septum and from the floor of the nose until enough slack is created (Fig. 2A) to permit the flaps to stay in the mid-line when complete healing has occurred. The cep-



FIG. 5. A and B, right and left profiles before corrections; C and D, right and left profiles after operation.

alad aspect of the columella is vertically incised separating the two medial crura from each other. An adequate strip of cartilage is placed into the columella to act as a strut. (Fig. 2B.) If there is not an adequate piece available from the septal cartilage fragment previously excised, a piece of pickled septal cartilage, or better yet, pickled rib cartilage can be employed. The remainder of the septal cartilaginous fragment can then be placed between the two mucoperichondrial flaps and left there as a cartilage graft. The upper lateral cartilages including this graft are then sewn together, using fine chromic mattress sutures. (Fig. 3.) The caudal edges of the mucoperichondrial flaps are then approxi-

mated to the membranous columella by interrupted silk sutures. To insure mid-line healing, vaseline packs or rubber tubes should be left in each nostril and nasal cavity for as long as may be necessary, that is until satisfactory fixation of the cartilage grafts has occurred. (Figs. 4 and 5.)

SUMMARY

An operative procedure has been outlined for repairing any type of septal cartilage dislocation or deformity. This is based upon the principle that one may, with safety, entirely excise a deformed septal cartilage and still support the nose by the use of the upper lateral cartilages and a columellar cartilaginous strut.

A METHOD OF PELVIC MEASUREMENT

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THE purpose of this paper is to simplify pelvic measurement. The principle is as follows: A metal ball of known diameter is inserted into the rectum. Lateral and anteroposterior x-rays are taken. The enlargement of the pelvis on the x-ray is accurately mirrored in the enlargement of the metal ball. Because this metal ball is located in the center of the pelvis it will be enlarged to the same degree as the rest of the pelvis.

On the x-ray films we measure the required diameter, and the diameter of the metal ball. An equation is drawn:

$$\frac{\text{X-ray of required diameter}}{\text{True diameter (X)}} = \frac{\text{X-ray diameter of metal ball}}{\text{True diameter of metal ball (1.27 cm.)}}$$

The x-ray of the required diameter is a known.

The x-ray of the metal ball is a known.

The true diameter of the metal ball is a known (1.27).

Thus we have an equation with three known factors and one unknown factor (X), and the result can be easily calculated.

A half-inch metal ball is used: this equals 1.27 cm. It would have been easier for purposes of calculation if the metal ball were exactly 1 cm., but such a ball is not obtainable in this country today. The half-inch ball is the ordinary metal ball used in ball bearings.

The procedure in greater detail as used on a patient is as follows: The metal ball is placed in a finger cot and tied with a string into the tip. The string is left long. The combination is lubricated and slipped into the rectum. When it passes the internal sphincter it naturally slips into the ampulla. The string is long enough to hang out of the rectum. X-rays are taken.

The string is pulled out to extract the finger cot and metal ball. The ball is taken out of the finger cot and can be washed and used repeatedly. Whatever diameter is required is found by setting up the proportion as described.

EXPERIMENTAL DATA

A pelvic bone is taken and important points that mark the diameters are marked with lead arrows. These are made by cutting a piece of sheet lead with a scissors. They are taped into position with scotch tape. The object of this maneuver is to be certain that the diameters measured on the x-ray film are the same as those measured on the bone itself. The metal ball is taped into position in the same location it would assume if it were inside the rectal ampulla. Anteroposterior and lateral x-rays are taken. A Bucky x-ray with the following factors is used: 30 M.A., 50 K.V., $\frac{1}{2}$ second, 30 inch distance. This purposeful overexposure accentuates the lead markers rather than the bone.

The actual diameter between two markers is measured, but is left as an unknown to test the accuracy of the method. The measurements taken on the x-ray film are: (1) the required diameter, (2) the diameter of the ball. A simple proportion is then set up:

$$\frac{\text{X-ray of required diameter}}{\text{True diameter (X)}} = \frac{\text{X-ray diameter of metal ball}}{\text{True diameter of metal ball (1.27 cm.)}}$$

$$X = \frac{(\text{X-ray of required diameter})(1.27)}{\text{X-ray diameter of metal ball}}$$

X-ray of required diameter of pelvis is known.

X-ray diameter of metal ball is known.

True diameter of metal ball is known. Thus we have three knowns and one unknown (X). From this the true diameter is calculated. It is checked against the true measurement between the lead arrows on the skeleton. The difference is the error.

In ten trials the error has not exceeded 0 to 6 mm. The position of the metal ball is such that the diameters of the inlet, outlet, mid-pelvis or fetal head can be measured from it as a basis.

SOURCES OF ERROR

The anteroposterior and lateral views should be accurate. A turning of the body away from anteroposterior or lateral positions will give a shorter diameter than the true one on the x-ray film.

In the experiments on the pelvic skeleton the lead arrows should lay straight, if they are bent the points will be distorted out of proportion on the x-ray film.

The centimeter rule should be accurate and if possible transparent. The rule used originally until replaced was off 1 mm. on a 15 cm. rule.

In the patient the pelvic bone is a curve in three dimensions. On the x-ray film it is only in two dimensions. It is not always easy to locate the exact point on the x-ray film that corresponds to the point on the pelvic bone in the patient. Of course this is overcome in the experimental work on the pelvic bone by the use of lead markers, but dealing with the patient becomes a more difficult matter.

The symphysis, especially the lower border, does not show in the lateral view as precisely as one would like it to, particularly in stout people.

CONCLUSION AND SUMMARY

A method of pelvic measurement is described which has as its principle the insertion of a metal ball of known diameter (1.27 cm.) into the rectum, taking x-ray films and calculating the true diameters by a simple proportion. It is simple and accurate, and can be taken with any machine, regardless of target to film distance. No special measuring devices, calculations or equipment is necessary.



KOROSEAL: A RUBBER SUBSTITUTE

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COMMON among the many problems confronting those concerned with the operation of any general hospital is that of rubber tubing. Increasing demands of modern medicine and surgery for new and different types of intravenous therapy make cleansing, sterilization, etc., of rubber tubing and connections of paramount importance if serious reactions are to be avoided.

Rubber tubing commonly used for intravenous sets, so-called hard rubber drains, and in blood and plasma transfusions, deteriorates rather rapidly under almost any type of repeated sterilization, and most men have had the disheartening experience of having an intravenous set spring a leak with the loss of precious fluids at a time when it could be least afforded.

In addition to its propensity for rotting, cracking and leaking under certain types of sterilization, rubber tubing tends to stick to itself and if it has been autoclaved with a glass connection in place, it becomes well nigh impossible to remove the connection, the tubing must be cut and the adhering rubber scraped from the glass.

Recently a number of workers have reported that the activity of penicillin, when administered through rubber tubing, is decreased by as much as 25 per cent.

One further serious drawback to rubber tubing is that it is non-transparent and following blood transfusions the cleansing of a length of rubber becomes a major operation. It is indeed difficult to be sure the lumen is entirely clean. When used as tissue or abdominal cavity drains hard rubber tubes, especially, often set up untoward reactions.

With these problems in mind the author began a series of experiments in 1941

using Koroseal as a substitute for rubber tubing.

This plastic material, controlled until recently entirely by the War Department, is superior in almost every way to rubber for common hospital usage. It is flexible, sturdy and withstands the rigors of any type of sterilization. One piece of the material supplied for experimental work has been boiled daily in the usual type office sterilizer for a period of three months with no appreciable change. One other piece is four years old and has been subjected to repeated sterilization and is as unchanged and flexible as in the new state.

The material is also unaffected by acids and alkalis and undergoes little if any change in body fluids when used for cavity or tissue drainage. In regards to cavity drainage Koroseal is radio opaque and shows up well either at the screen or on the film.

One great advantage to Koroseal we found in the first sample supplied was its crystal clearness. Fluids may be observed passing through the tubing as well as if it were clear glass and the cleansing problem is reduced to a minimum for this reason. It also facilitates starting intravenous fluids enabling the operator to note the absence of bubbles, height of column of fluid, etc., in the tubing. The clear character of the tubing is altered by boiling, a white cloudy appearance showing up, but this disappears once complete cooling has taken place.

The only serious drawback we have encountered with Koroseal is that it is only slightly elastic and there is some slight difficulty in making connections. Plastic or glass connections with a one screw turn adaption, however, largely do away with this objection.

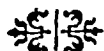
At the present time the supply of Koroseal tubing is limited to experimental quantities, but we believe that it will do much to solve the common hospital tubing problem once it is released for full production.

SUMMARY

Koroseal, a plastic substitute for common rubber tubing for hospital use, is

presented. Its advantages are: (1) It is almost indestructible to ordinary sterilizing methods. (2) It is transparent, thus facilitating the administration of intravenous fluids and at the same time making the cleansing problem much simpler. (3) It is radiopaque and can be manufactured in whatever size seems most desirable.*

* Koroseal tubing used in this work was supplied through the courtesy of the United States Navy and the B. F. Goodrich Company, Akron, Ohio.



STREPTOCOCCI are Gram-positive organisms, which grow in chains and comprise many different strains. Also members of the same strain often develop varying degrees of virulence.

From "A Short Practice of Surgery" by Hamilton Bailey and R. J. McNeill Love (H. K. Lewis & Co. Ltd.).

INDIRECT INGUINAL HERNIA

REPAIR OF THE ANATOMICALLY WEAK AREA

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IN 1942, McVay and Anson, on the basis of sound, illustrated anatomic studies, published their recommendations for inguinal hernia repair. Briefly, they advocate the suture of the transversus abdominis aponeurosis to Cooper's ligament in the lower reaches of the inguinal canal, from the pubic tubercle to the sheath of the femoral vein. The intervening defect between the femoral vein and the internal inguinal ring they close by suturing transversalis fascia to the anterior surface of the femoral sheath. This type of repair utilizes fascial tissues entirely and is laudable on that count alone. In addition it strengthens the posterior wall of the canal and closes the femoral ring, insuring against both direct and femoral hernia.

We further strengthen the floor of the canal in the defect between the femoral vein and internal ring by suturing the transversus abdominis aponeurosis to the deepest portion of the reflected part of Poupart's ligament. Otherwise we are in complete agreement with the McVay procedure. However, for indirect inguinal hernia there is logically and anatomically one step more.

Consider the nature of indirect inguinal hernia in relation to the recognized and advocated types of repairs. In common, they all reinforce the floor of the canal with muscle or fascia at one level or another in order to prevent recurrent hernia. However, the indirect inguinal sac, whether congenital or acquired, protrudes through the arch of the abdominal ring. Not in the floor of the canal, but in the arch of the abdominal ring is the structural anatomic defect through which the herniation occurs. At that point the descending testes pushed the abdominal layers ahead of it and left the attenuated tissues as the coverings of the cord. Of

these, the internal spermatic, which is the prolongation of the transversus abdominis aponeurosis, is continuous with it. The transversus abdominis aponeurosis forms the fascial arch of the internal ring.

Technic. The logical step in the repair of indirect hernia follows: The cord is opened by incising the cremasteric muscle and spermatic fascias. The isolated sac is ligated at the neck and the excess excised. The ligated neck is then allowed to retract through the abdominal ring deep to the transversus abdominis arch. It comes to rest at the level of the transversalis fascioperitoneal layer of the abdominal wall. The internal and external oblique muscles are retracted upward fully exposing the internal inguinal ring. The aponeurosis on either side of the arch is grasped in Allis forceps and drawn together anterior to the ligated sac neck; imbricating mattress sutures are used to hold it in place. Thus, a double aponeurotic layer is interposed anterior to the ligated sac neck. A double aponeurotic layer is also left in place of an anatomic defect. This, then, is our insurance against recurrent herniation at this point. The remainder of the repair proceeds in the fashion advocated in the initial paragraphs.

SUMMARY

The logical procedure for repair of indirect inguinal hernia is to interpose a fascial layer anterior to the ligated sac neck.

This is done by approximating the transversus abdominis aponeurosis at the arch of the internal ring, thus closing over the anatomically defective area.

REFERENCE

- McVAY, C. D. and ANSON, B. J. A fundamental error in current methods of inguinal herniorrhaphy. *Surg., Gynec. & Obst.*, 74: 746, 1942.

INTRA-ABDOMINAL PLACEMENT OF DRUGS

A SIMPLE METHOD

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AND

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THIS paper does not intend to discuss the merits or demerits of the intra-abdominal use of the various powders and crystals but rather the difficulties encountered in using the same and to suggest a simple method for overcoming some of them.

Everyone who has used the various powders and crystals, whether in salt shakers, paper packets, or the commercial crystals in the paper shaker, has had the unpleasant experience of having most of the drug adhere to the retractors, wet gloves, stray loops of bowel, and the wall of the incision with the masking of the structures.

The equipment consists of a glass tube three-fourth inch in diameter, twelve inches long, and well annealed at both ends, and a plunger of wood roughly one-fourth inch in diameter and eighteen inches long.

The tube is packed with varying amounts (2, 4, 6, 8 Gm., depending upon the choice of the surgeon) of the drug selected. The ends of the glass tube are plugged with cotton. The tube and plunger are then wrapped together and autoclaved. They are then ready for use.

The method used is as follows: In the case of a perforated appendix with peritonitis. The operation is completed, and the first one or two peritoneal stitches

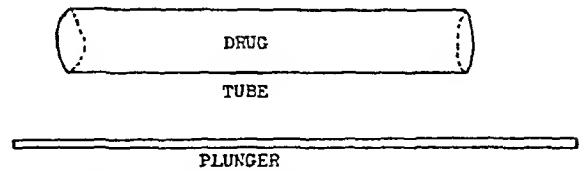


FIG. 1. Illustration of tube and plunger.

taken. The tube is then taken by the operator, the cotton plugs removed, and it is inserted down so that the end rests in the bed of the appendix. The plunger is then inserted into the tube, and with repeated gentle strokes small portions of the drug are inserted into the desired area until the tube is empty. The tube is then withdrawn and closure completed. Some of the drug remaining in the tube is sprinkled into the layers of the wound.

In this manner, it is possible to place a known quantity of the drug at any desired spot without having it removed from the abdomen by the surgeon's hands and instruments.

It is important that the plunger be considerably smaller than the caliber of the tube, for when using a close-fitting plunger, it was found that the drug was expressed in a solid plug which tended to form a cake.

This method has been used in the Jefferson Hospital, Roanoke, Virginia, for four years and has proved to be the most satisfactory of all methods tried for the local application of the drugs.



Case Reports

ABDOMINAL TYPE OF ECTOPIC PREGNANCY

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SINCE the normal place for a pregnancy is within the uterine cavity, an ectopic pregnancy may be defined as that condition in which the embedding growth of the impregnated ovum takes place elsewhere than in the uterine cavity. The term, extra-uterine pregnancy, may be used as a synonym for ectopic pregnancy, meaning that the fertilized ovum may become implanted in the tube, in the ovary or anywhere in the abdominal peritoneum. While an interstitial pregnancy is the usual type of ectopic pregnancy, most cases of ectopic gestation occur farther out in the tube proper. Of the tubal variety most take place in the tubes' outer half or middle. While embryos have been found in the lower uterine segment, in the canal of the cervix and even within the vagina, such cases would be regarded more correctly as forms of abortion rather than true ectopic pregnancy. Occasionally, a pregnancy occurring in the infundibulum projects itself into the abdominal cavity. Whether or not a pure form of abdominal pregnancy ever exists is still open to question in the minds of many. Cases of abdominal pregnancies occur in which the sac ruptures and the fetus is then discharged into the body cavity. In such cases development is possible so long as the placenta remains intact and communication with the mother is maintained. Usually, however, when the fetus is discharged into the abdominal cavity it becomes encapsulated and degenerates. Mummification, maceration or calcareous infiltration (Lithopedion formation) may occur.

In the vast majority of instances extra-uterine pregnancy results from the nidation of a fertilized ovum in some portion of the mucosal lining of the Fallopian tube.

It is generally accepted in women with a twenty-eight day menstrual cycle that ovulation usually takes place between eleven and fifteen days following the onset of the preceding menstruation. It has been established by direct observation that the ovum is slowly extruded on to the surface of the ovary from the ruptured follicle. The ovum is engulfed almost immediately by the fimbriated end into the tube which has been known to assume usual activity at the time, sweeping back and forth over both surfaces of the ovary.

It has been held by good men that nidation can take place only in Müllerian tissue. If this is true, there is no such condition as a primary peritoneal pregnancy. Studdiford¹ maintains that there is a primary peritoneal pregnancy.

My first case leads me to believe that such a condition is possible, for the reasons that both tubes and ovaries were normal, there was no evidence of recent or remote injury to the tubes, there was an absence of any evidence of uteroperitoneal fistula and the pregnancy seemed related to the peritoneal surface. However, primary abdominal pregnancies are not common.

The course of these cases may vary greatly and many symptoms may be presented by the patient causing confusion. The usual history is that the patient has missed one or two periods and then suddenly she develops severe, cramp-like

pains in the lower abdomen. She may pass a small amount of blood, have a chill, become dizzy, nauseated and ultimately collapse. The patient may have a history of previous severe menstrual cramps or of pelvic inflammation. The picture becomes cloudy especially when the symptoms are of peritoneal manifestations.

The diagnosis is not so easy before tubal abortion or tubal rupture has occurred, because the mass is soft as an intestinal loop. It has been said that the way to tell a case of tubal abortion from tubal rupture is that when you see your patient, if she is alive it was tubal abortion, and if she is dead it was tubal rupture and a fatal hemorrhage has occurred. This was known as Harris' rule. However, I have rescued a few tubal ruptures that were leaking slowly. It is important that the doctor carefully sift the history, evaluate all factors, and always listen to an intelligent patient, because she frequently can be of much aid in diagnosis. A careful, gentle, pelvic examination to determine the size and consistency of uterus is of great importance.

The question of the time to operate is, in my opinion, as soon as the patient's condition will allow. The earlier the surgical interference, the better it is for the patient. There also arises the question of what to do with the placenta in abdominal pregnancies at operation.

There are three usual methods of handling these: (1) Complete separation and removal; (2) marsupialization or partial closure and drainage; and (3) leaving the placenta *in situ* with or without drainage. The placenta will usually become absorbed in a short time.

The following are two cases that occurred in my practice within the period of a year:

CASE REPORTS

CASE I. Mrs. E. R., age thirty-seven, para 6, came to my office complaining of cramping pains in her right side and of chills and fever of three days' duration. Her pulse was 110, temperature 102°F., respiration 24, blood pres-

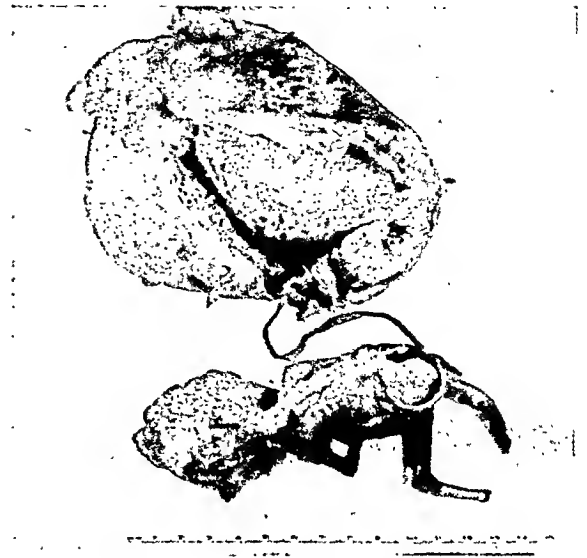


FIG. 1. General view of mass with fetus; gestation sac partly opened.

sure 110/70, and hemaglobin 14 Gm. When questioned concerning her menstrual history, she stated that four months previously she had missed one menstrual period, but since then had menstruated one or two days during her regular menstrual time. She had been to a physician and had been told that she had "female trouble." This later proved to be true. Upon physical examination the abdomen was tense and rigid. A pelvic examination revealed a large soft mass, the size of a grapefruit, situated to the right of a small firm uterus. She was hospitalized and given 2,000 cc. of 10 per cent glucose intravenously daily, for two days and also 1 Gm. of sulfadiazine every four hours.

Her temperature was normal on the third day and under spinal anesthesia her abdomen was opened. A four months' fetus was found in the peritoneal cavity with a moderate amount of hemorrhage. The placenta was attached to the omentum and intestines. The tubes and ovaries revealed no gross evidence of recent or remote injuries or of inflammation. The fetus and placenta were completely removed and 10 Gm. of sulfanilamide crystals were placed in the abdominal cavity and the abdomen closed without drainage. The patient was discharged from the hospital on the twelfth day as well. I believed that this was probably a case of primary peritoneal pregnancy.

CASE II. Mrs. E. F., age twenty-six, para 0, gravida 1, was admitted to my surgical service on October 5, 1945, with a complaint of a painful mass in her lower abdomen.

FIG. 2.

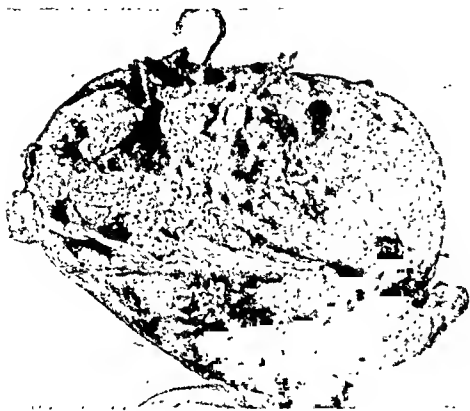


FIG. 3.

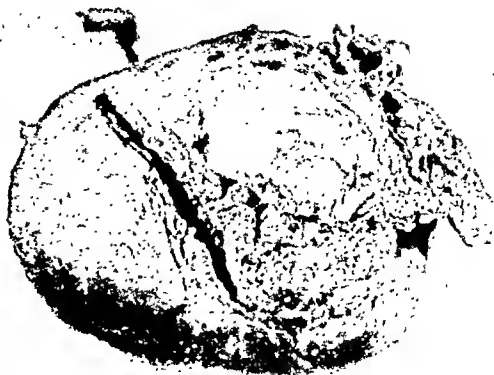


FIG. 4.

FIG. 2. Mass from one side, showing tube and umbilical cord.

FIG. 3. Mass from other side, showing again tube and umbilical cord and also ovary (white patch).

FIG. 4. Cross-section showing ovary and tube at periphery, well separated from placental mass which shows amniotic cavity with inserting umbilical cord.

FIG. 5. Cross-section through other level, showing again very thickened, fibrotic and adherent tube, as well as ovary with small follicle cyst both separated from placenta; tube blends into placental mass.



FIG. 5.

Her last menstrual period was May 10, 1945. General examination revealed an anemic, female, colored patient whose blood pressure was 90/60, pulse 120, temperature 102°F. Physical examination showed normal chest findings. In the abdomen there was a smooth mass extending up to the level of the umbilicus most marked on the right side. The abdomen showed generalized tenderness and the mass was hard and irregular. The pelvic examination revealed the cervix to be posterior, closed and firm. Her hemoglobin was 9.5 Gm., red cell count 3,200,000, and total white count 12,000. The urine was negative except for 1 plus albumen. Because of the history, it was believed that the patient was suffering from intraperitoneal hemorrhage due to an ectopic pregnancy.

She was given a transfusion of 500 cc. whole blood, and under spinal anesthesia a laparotomy was done. On opening the abdomen through a lower abdominal mid-line incision, the peritoneal cavity was found to be filled

with fluid and clotted blood. The right tube was inflamed and fastened down to the back of the uterus. The uterus was in normal position and not enlarged. On the posterior aspect of the broad ligament a placenta was firmly attached, and free in the abdominal cavity was a three month's fetus. The placenta and fetus were removed with very little hemorrhage; 10 Gm. of sulfanilamide crystals were placed in the abdominal cavity and the abdomen was closed without drainage. The patient made an uneventful recovery and was discharged fifteen days after operation with the wound well healed and no complaints.

The pathological report October 16, 1945, in Case 11 is as follows: Pathological No. B 1399; Macroscopically, the abdominal mass measured 15 by 13½ by 9½ cm. The mass was covered almost throughout with scrota and at one point it was considerably thickened. The tube could be identified at its outside with the isthmic portion severed from the uterus and the ampullary portion with its fimbrial

end blending into the mass. Close to the tube, the ovary could be identified as a disc-like mass measuring 5 by 3 cm., and contained several small cysts. This ovary also blended with the mass. Part of the ovary, however, and the isthmical portion of the tube could be separated from the mass which appeared to be composed of friable solid hemorrhagic tissue resembling placental tissue. Over an area measuring $6\frac{1}{2}$ cm. in diameter, the mass was not covered with serosa and in this area a very thin umbilical cord was found to be inserted at the umbilicus and measured 9 cm. in length and 2 mm. in width.

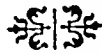
Microscopically, the large mass consisted of isolated necrotic chorionic villi embedded in masses of blood clots and fibrin. This necrotic placental tissue was found to be inserted in

the wall of the fimbriated end of the tube and separated from the ovary and from the ampullary portion of the tube by granulation tissues rich in blood pigment and lipoid filled histiocytes. The Fallopian tubes showed a severe purulent chronic inflammation involving all layers of the wall. Where the gestation sac was not adherent to the ovary and tube, it consisted of fibrotic granulation tissue. An amnion could be identified lining the inside of one vein and two arteries. The ovary contained follicular cysts.

Diagnosis: Abdominal pregnancy of four months' duration around the fimbriated end of the tube; chronic purulent salpingitis.

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1. STUDDIFORD, WM. E. *Am. J. Obst. & Gynec.*, 44: 487-491, 1942.



HERNIA PERICARDII*

COMDR. A. LINCOLN BROWN AND LIEUT. SYDNEY F. THOMAS
MEDICAL CORPS, UNITED STATES NAVAL RESERVE

THE pericardium is a sac composed of two layers, the outer fibrous and the inner serous. An abnormal bulge or protusion of both fibrous and serous layers may well be termed a pericardial diverticulum. The protusion of the serous membrane through a defect in the fibrous layer should be designated hernia of the pericardium (*hernia pericardii*).†

A tabulation of all reported instances of diverticula of the pericardium was made in 1937 by Cushing¹ which, with the addition of a personal case, totaled forty. It is of interest to note that, correctly or incorrectly, the first two reported cases were entitled "Hernia."^{2,3} The communication between the pericardial cavity and the diverticulum or hernia, may be broad, minute, or slit-like and it may become obliterated leaving a cystic mass lined with pericardial serosa as in instances reported by Yater⁴ and Dufour.⁵ The majority of observations noted in the literature were postmortem findings; six diagnoses were based solely on x-ray examinations and some masses were calcified. Many of the reports are inconclusive as to the pathological condition of the retaining walls, so that exact classification is not possible.

In the case reported by Cushing,¹ the diagnosis was made when aspiration of a swelling to the right of the sternum with replacement by air showed direct continuity of the parasternal mass and the pericardium.

The present case is reported because of the unusual rarity of the condition. The

† It is the opinion of the authors that the term "*hernia pericardii*" is a more correct term than "*diverticulum of the pericardium*."

fact that, in retrospect at least, all previously advocated diagnostic aids are exemplified, an additional diagnostic method, roentgen kymography, is presented; and the surgical removal of the hernia in this instance apparently constitutes the first time this procedure has been reported.

Etiology. These lesions may arise upon either a congenital or an acquired basis. A weakness or defect of some area of the pericardial layers must exist in either case. Normally, there are potentially weak areas along the lines of reflection where the parietal pericardium separates from the two serous layers and merges into the adventitia of the great vessels. To a lesser degree such a potential weakness also exists at every point of entrance of the pericardiac vessels and nerves as well. The acquired cases are considered to result from the further addition of disease (pericarditis, lues, etc.) upon these potentially weak areas or through the direct weakening of any portion of the pericardial wall by local disease or trauma. Obviously any unusual increase in intrapericardial pressure would tend to bulge out a weak spot regardless of its origin.

The acquired cases have also been classified as either pulsion diverticula or traction diverticula by Juderholm.⁶ Pulsion diverticula are assumed to develop on the basis of increased intrapericardial pressure and traction diverticula from an external force or pull as might exist from mediastinal adhesions or the weight of an unusual accumulation of pericardial fat.

Diagnosis. The majority of reported instances have been discovered postmortem. By far the greater number of cases

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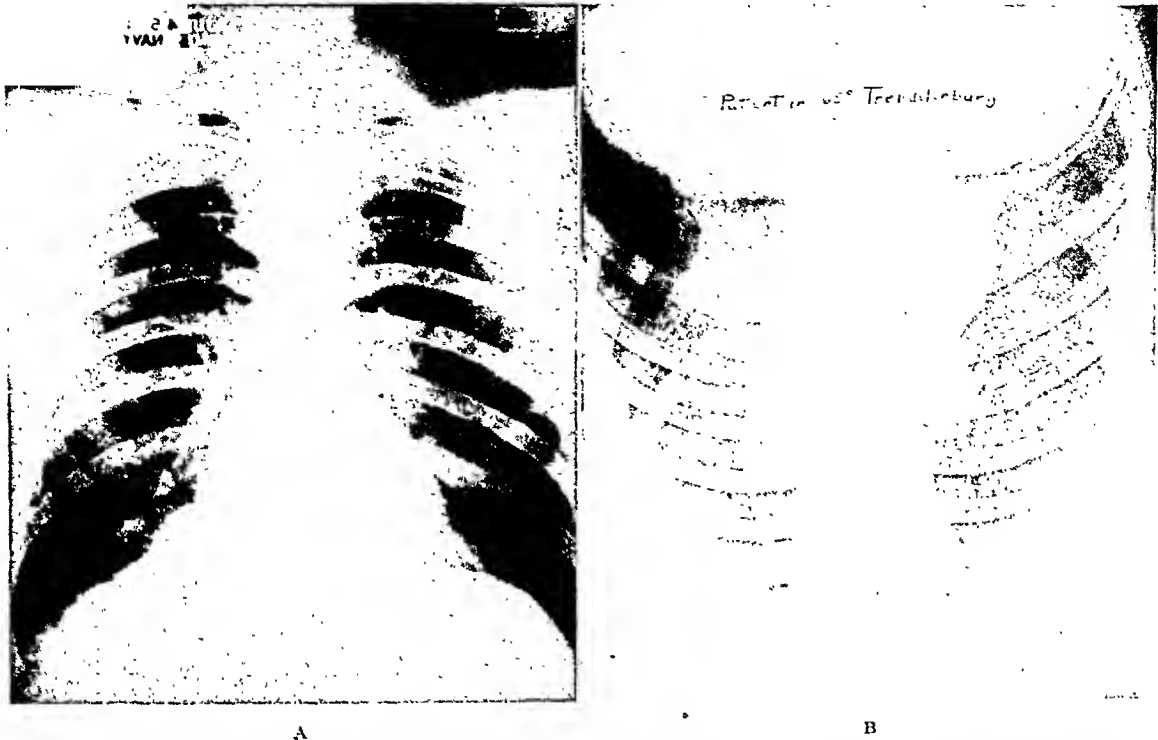


FIG. 1. A, shows the rounded shadow of uniform density to the right of the heart and lying on the diaphragm. B, patient in 65 degree Trendelenburg position. With a pneumothorax, mass is no longer visible, having been displaced by change in position and much of its fluid content having flowed into the true pericardial sac.

have had no symptoms directly attributable to the lesion though may have had intrathoracic (usually cardiac) findings. These symptoms could well be explained by other more common disorders in each individual case.

Recently roentgen ray has made possible at least a tentative diagnosis of the condition during life. Kienböck and Weiss,⁷ in 1929, pointed out that a soft tissue shadow, arising from and continuous with the heart shadow, whose lateral border was sharply defined and which showed a moderate pulsation was consistent with and should lead to the consideration of the possible existence of a pericardial diverticulum.

Jansson,⁸ in 1931, added an additional highly important x-ray observation. He noted a change in size and shape of the soft tissue shadow with respiration; upon respiration the shadow became longer and narrower while it expanded on expiration. This plasticity is not observed in either a solid tumor or in the vascular system.

An additional diagnostic aid may well be kymographic studies. Thus in the case presented herewith the kymogram shows

definite increased pulsations in the area of the wall of the soft tissue shadow. One might postulate that the greater the evidence of pulsation in the suspected mass the larger the communication between the true pericardial sac and the hernia or cavity of the diverticulum.

CASE REPORT

This white male, twenty-four years of age, was admitted to the Oakland Naval Hospital for clinical investigation because a routine photofluorographic chest examination had revealed a "tumor mass of unusual character in the right cardiophrenic angle." He had no complaints. The past history was entirely negative save for a severe attack of bilateral pneumonia at the age of seven for which he was kept in bed for months.

Examination revealed a well developed and well nourished white male in no acute distress. The heart was not enlarged to percussion; the rate and rhythm were normal; no murmurs were heard. Blood pressure was 135/70. Examination of the abdomen elicited no masses, tenderness or spasm. The liver and spleen were not felt and there was no costophrenic angle tenderness. Routine blood and urine examinations

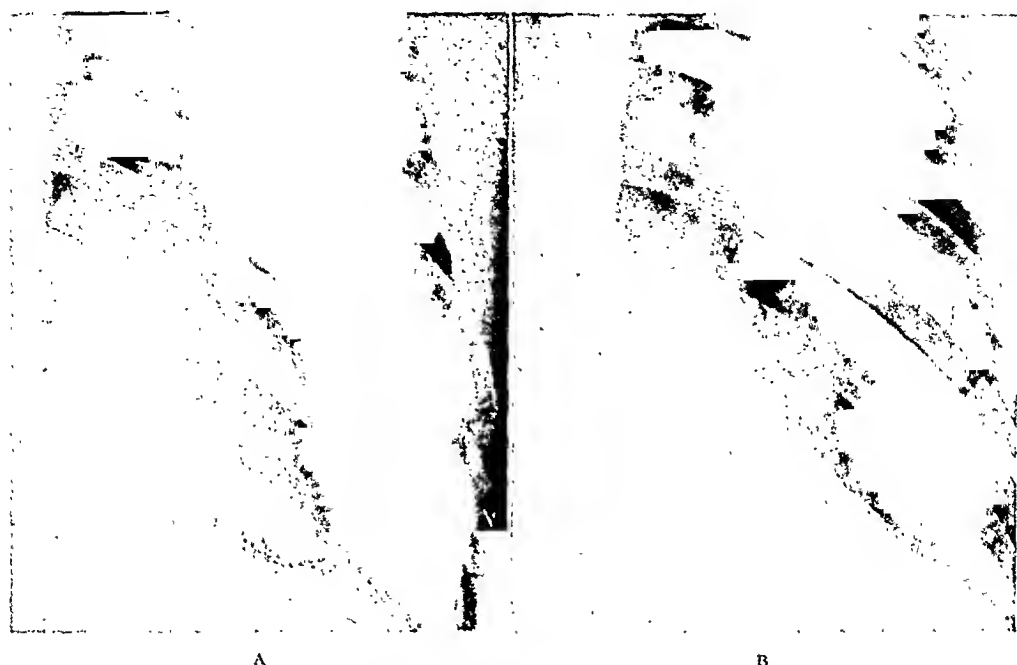


FIG. 2. Comparative oblique films, after a pneumothorax had been instituted, taken on inspiration (A), and expiration (B), of right cardiophrenic region showing change in size and shape of hernial mass under these conditions (observations of Jansson⁸). The mottled density in these films results from retained lipiodol.

were all within normal limits. The Kahn test was negative, and the sedimentation rate was 2 mm. per hour. (Figs. 1A and B.)

An attempt to determine the nature of the original shadow observed by x-ray was made by the following studies which are presented in chronological order:

1. Fluoroscopy (chest): Thickened pleura at the right costophrenic angle; chest otherwise normal.

2. Bronchogram: Bronchi to both lower lobes are not remarkable. The density noted in the region of the pleural pericardial reflection on the right is seen.

3. Gastrointestinal Series: Esophagus, stomach and duodenum normal. Progress studies made at three and twenty-four hours disclosed the barium to lie in the lower small bowel and colon which appeared entirely normal.

4. Chest x-rays: Fluoroscopy and Kymography: Review of all the films, including the examination of July 18, 1945, shows a rounded uniformly dense mass in the anterior inferior portion of the right thorax mesially. The present examination shows a pneumothorax with about 70 per cent collapse of the right lung, and the mass is clearly delineated and free in the pleural space.

The special films made in the oblique posi-

tion and in expiration confirm the fluoroscopic finding that the mass is free in the pleural space. (Figs. 2A and B.)

A film made with the head down reveals the right leaf of the diaphragm to have normal contour. (Fig. 1B)

Fluoroscopically and on the kymographic studies of the cardiac silhouette the mass pulsates with the heart but there is no evidence that the lesion is expansile. (Fig. 3.)

Conclusion: "Soft tissue tumor, pulsates with the cardiac pulsations, and measures approximately $10 \times 4 \times 3$ cm.

"The best possibility is a dermoid cyst or some sort of a congenital anlage. The intimate connection with the pericardium is suggestive that it arose there, but the more likely is that it arises in the mediastinum, as the curvilinear appearance of the tumor toward the hilar region suggests a more mesial origin than is demonstrable on these films."

5. Electrocardiogram: Within normal limits.

6. Thoracoscopy: Lying on top of central portion of the diaphragm (right) was seen a bluish, apparently tubular structure over the lateral wall of which there appeared to run a fibrous band (like a tinea). Vessels similar to those seen on the intestine came up from both sides. Beneath the loop was another mass of

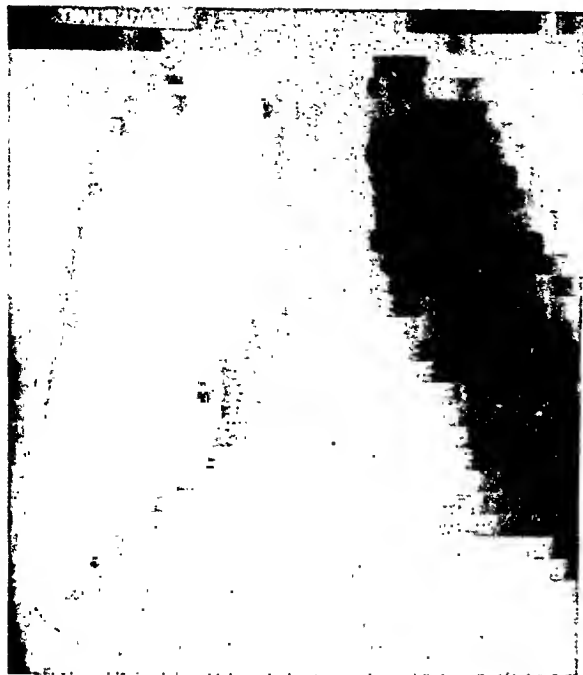


FIG. 3. Kymographic tracing showing increased pulsations in the mass to be greater than in the remaining portions of the pericardial wall. (Diagnostic aid observed in case reported herewith.)



FIG. 4. Specimen removed at operation. Clamp is on tubular structure by which the entire multi-lobular lumen of the mass communicated directly with the pericardial cavity. Photograph taken after the specimen had been filled with saline through its tubular projection.

the same color covered by vessels and in one area pulsating slightly. Large bowel hernia is a possibility,—otherwise diagnosis of mediastinal anlage must be maintained.

On October 5, 1945, an exploratory thoracotomy was performed with the diagnosis (pre-operative): mediastinal rest. The procedure and findings were an intercostal incision, seventh interspace posterior; segments of the eighth and ninth ribs 1 cm. in length were removed subperiosteally. The pleura was opened, and the lung was found well collapsed by a previous pneumothorax. A cystic lobulated mass was found on the right lateral wall of the lower half of the pericardium, measuring about 7.5 by 10.0 cm. This was freed by sharp dissection and ultimately found to be connected directly to the pericardium by a patent tract, the lumen of which was approximately $\frac{1}{2}$ cm. in diameter. The pericardial fluid was seen to swish back and forth between the cystic dilatation and the normal pericardial sac on each systole. The neck of the sac was doubly ligated with a ligature which had been sutured to the fibrous pericardium at its base. The sac was removed *in toto*. (Fig. 4.) The wound was closed in layers after 100,000 units of penicillin in 300 cc. of saline were instilled into the pleural cavity. The pneumothorax was completely removed by placing a catheter

under water. The postoperative course was uneventful.

Pathological examination revealed the following: *Gross specimen:* The specimen consists of two irregularly shaped pieces of tissue submitted in Zenker's solution. The largest measures 5 by 3 by 2 cm., the smaller 4 by 3 by 1 cm. The smaller has the appearance of lobulated adipose tissue. On section, the larger is biloculate containing a yellow pasty material. Its wall averages 0.1 cm. in thickness. It is lined by wrinkled yellowish-grey membrane. Its capsule is intact. *Microscopically,* The wall is composed of an outer zone of dense collagenous connective tissue in which there are prominent perivascular collections of lymphocytes. A lining membrane is made of flat, polyhedral cells with large pale nuclei. The nuclei possess one or two prominent nucleoli. The cytoplasm is abundant and faintly acidophilic. There is no evidence of malignancy. Sections of the adipose tissue show no significant change.

The diagnosis is: Hernia, pericardial, serosal, bilocular and normal tissue, fatty.

The authors wish to draw attention to an article by Morton L. Mazer on "True Peri-

cardial Diverticulum" which appeared in the January, 1946 issue of the American Journal of Roentgenology. This case is very similar to the one which the authors report herein.

SUMMARY

1. A brief resume of the cases of hernia, diverticuli and cysts of the pericardium previously reported in the literature is given.

2. The possible etiology of these lesions is discussed.

3. The diagnostic measures which might lead to the correct diagnosis during life are enumerated.

4. The additional diagnostic value of roentgen kymography is presented.

5. The first case of pericardial hernia to be removed surgically is reported.

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SPONTANEOUS CLOSURE OF RECTO-URETHRAL FISTULA FOLLOWING PERINEAL PROSTATECTOMY

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INJURY to the rectum following urological procedure is uncommon, though such trauma may occur following cystoscopy, use of sounds, transurethral prostatectomy and perineal prostatectomy. The operative procedure most likely to result in a perforation of the rectum probably is perineal prostatectomy. This complication has been quoted as one of the possibilities ever since this technic was devised. This is no indictment of an excellent surgical procedure. Excluding inexperience in perineal dissection, it should be rare even in patients with so-called "thick" perineums and close-set ischial spines, or "narrow" perineums.

While many writers mention recto-urethral fistula as a possible complication, there has been little in the literature to guide one by this embarrassing complication. The usual practice is to divert the urine by suprapubic cystostomy, followed by a closure of the fistula. Added to this, colostomy to divert the feces has been done in order to secure a clean field for closure of the fistula. Young and Stone reported in 1913 a radical technic for repair of a recto-urethral fistula. C. R. Davis, and more recently, Rusche and Bacon, have reported successful experiences with this technic. Corbus and Corbus recently reported spontaneous closure of a recto-urethral fistula after a suprapubic cystostomy had been done.

The writer believes the more modern technics of perineal prostatectomy have reduced the seriousness of injury to the rectum. In the original technic and earlier modifications of it, no attempt was made to do a plastic repair of the vesical neck; nor was the incision in the prostatic capsule

sutured. In the older operative procedures, if the Davis hemostatic bag is used, the incision in the capsule cannot be closed. Urine, therefore, seeps around the bag to saturate the wound. If perforation of the rectum has occurred, fecal drainage further complicated matters and spontaneous epithelization cannot be expected.

In the technic of perineal prostatectomy, as modified by Young and reported in 1928, and by Gibson, Hinman, Belt, Johnson and others, the bladder neck is sutured to the prostatic capsule and the curved incision in the capsule then closed snugly. The wound is closed around a small Penrose drain and a urethral catheter is used for urinary drainage. Usually there is very little leakage of urine through the wound with this technic. In the majority of cases, the wound will be dry and healing by the fifth or sixth day. Should the rectum be perforated, evidences of fecal drainage will be present six to ten days postoperatively. By then, primary union of the incision in the prostatic capsule, in most instances, will have occurred. Profuse urinary drainage through the wound will be avoided. Conservative management can then be employed. Immediate suprapubic cystostomy is not necessary. A careful rectal examination should be done to locate the rectal opening. Gentle irrigations of the wound should be done twice daily. A sulfonamide solution may be used, though this point is probably unimportant. Sulfaguanidine orally may be of some aid in sterilizing the lower bowel. Every attempt should be made to keep the feces soft. Rectal tubes should be avoided. A rectal examination one week later should reveal a "puckering" of the fistula. Con-

tinued treatment will result in a decrease in the fecal drainage until only a small amount of local wound infection remains after the fistula has closed. Further care can be managed outside the hospital.

CASE REPORTS

CASE I. F. K., aged fifty-four, was admitted to the hospital because of a partial urinary obstruction. The prostate was large (grade iv) and felt benign per rectum. A perineal prostatectomy was performed July 28, 1942. Following euclecation, the bladder neck was approximated closely to the prostatic capsule with three mattress sutures. The incision in the capsule was then carefully sutured after a No. 24 French Emmett balloon catheter had been inserted through the urethra. The levator ani muscles were approximated with two sutures of plain catgut and the wound closed around a plain Penrose drain to the prostatic capsule.

The patient was permitted to get out of bed on the third postoperative day. There was only a moderate amount of urine drainage through the wound, necessitating re-dressing twice daily. On the seventh postoperative day, the Penrose drain was removed. The wound appeared to be healing well. On the eleventh postoperative day, a small amount of purulent drainage was noted on the dressing. The next day, an enema revealed fecal material seeping through the incision. Rectal examination disclosed an opening in the rectum about 1.5 cm. in diameter on the right side. A No. 10 French soft rubber catheter was inserted into the right angle of the wound and gently irrigated twice daily with a sulfathiazol solution. Sulfaguanidine was given orally. Bowel movements resulted in appearance of feces in the wound. However, very little urine drainage seemed to be present.

Under this program, the wound slowly healed. The irrigations became less dirty and purulent. No urine drainage was apparent on the fifteenth postoperative day. The urethral catheter was removed on the nineteenth postoperative day and the patient subsequently voided freely and with good control. The wound became shallow and fecal drainage was noticeably scarce. The patient was dismissed thirty-three days following surgery and twenty-two days after discovery of the fistula. A small

opening still remained. This was irrigated and dressed daily until complete wound closure was effected on the forty-third postoperative day.

This patient was examined two months following surgery. The perineal wound was firm; the rectum likewise felt normal.

CASE II. F. G., aged sixty-nine, was hospitalized because of complete urinary obstruction. The prostate per rectum was large (grade iv), smooth, and felt benign.

A perineal prostatectomy was performed on December 15, 1943. The rectal wall appeared to be unusually thin. A small opening was made in the rectum while freeing the recto-urethralis fibers. The opening was immediately sutured with No. 000 plain catgut inverting the rectal mucosa. The suture did not penetrate the full thickness of the rectum. The adenomatous prostate was then enucleated through a curved incision in the capsule. The bladder neck was grasped with long Allis forceps for retraction. It was then sutured to the capsule laterally and posteriorly with three mattress sutures. The incision in the capsule was sutured after a No. 24 French Emmett catheter had been inserted through the urethra into the bladder. The levators were not approximated. The divided central tendon was sutured and the wound closed after packing the wound with sulfathiazole crystals. A single plain Penrose drain was used.

The patient was permitted to get out of bed the next day. The wound appeared to be healing normally on the fourth postoperative day. Very little urine seepage was apparent as only one daily perineal dressing was necessary. However, on the eighth day, fecal drainage was apparent. Rectal examination revealed an opening in the anterior rectal wall about 1 cm. in diameter and about 2.5 cm. from the anal margin. The right edge of the incision was not healed. A No. 10 French soft rubber catheter was inserted twice daily through this unhealed portion of the incision and the wound gently irrigated twice daily with a sulfathiazole solution. Sulfaguanidine was given by mouth. By the fifteenth postoperative day, the irrigations of the fistula returned somewhat cloudy but without fecal drainage. There had been no apparent urine drainage after the rectal fistula was observed. Several days later, rectal examination disclosed a puckering of the fistula with no apparent opening. The urethral catheter

was removed on the eighteenth postoperative day and the patient was able to void freely with good control. No urine leakage occurred from the wound. He was dismissed from the hospital on the twenty-third postoperative day. A small perineal dressing changed daily cared for the slight purulent drainage which persisted. This patient was examined two months later and the perineal wound and the rectum found to be perfectly healed.

In the first patient, fistula resulted from inclusion of the rectal wall in a suture of the levator ani muscles. Ordinary care in this approximation will prevent this complication. In fact, it is not necessary to suture these muscles as has been demonstrated many times.

More careful dissection of the perineum in the second patient would have probably prevented the tear in the rectal wall, though in rare instances, exceptionally friable rectal walls are encountered. Immediate suture should be done but a fistula is almost certain to result.

CONCLUSION

Spontaneous closure in two cases of recto-urethral fistulas is reported. Diversion of the urine or feces was not necessary.

Perforation of the rectum should be a rare occurrence if ordinary care is used in the technic of perineal prostatectomy.

Should it occur, it need not be a serious complication if reconstruction of the bladder neck and complete closure of the capsular incision has been done. Simple irrigations done gently through the drainage opening at the angle of the wound should bring spontaneous healing of the rectal fistula. Because the prostatic wound is snugly closed, urine drainage will be absent or negligible. Suprapubic cystostomy should not be performed until this simple clinical management has failed.

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RETROPERITONEAL FIBROMA WITH CALCIFICATION*

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PRI-MARY retroperitoneal tumors of indeterminate origin are relatively rare. Frank¹ has reviewed the literature from the period 1925 to 1936, finding 107 cases and adding three of his own. In this category pure, unattached fibromas appear to be especially rare. Wolfer,² in 1934, presented a case and reported finding only eleven others in the literature. We have been able to find reports of only two cases since 1934, these being by Fulton³ and by Luciani.⁴ Therefore, we believe our case to be of sufficient interest to warrant reporting.

CASE REPORT

The patient, C. W., was admitted to our institution April 7, 1945, with the complaint of a mass in the abdomen of nine years' duration. In 1920, he was kicked by a mule in the left lower posterior chest region. There had been recurrent dull pain in this region, accentuated by stooping or lifting, dating from the time of the injury. In 1936, he first noticed a swelling in the left upper quadrant and this had steadily increased in size. For the six months previous to admission he had had vague abdominal complaints associated with occasional vomiting of small amounts of food. There was shortness of breath and the patient was unable to work. During this latter period he had lost twenty pounds in weight. There was a history of recurrent attacks of malaria in childhood and up to 1910. Physical examination revealed him to be well developed and nourished. He was deeply tanned but otherwise there was no unusual pigmentation of the skin.

There was a large, very firm mass causing a protrusion of the abdominal wall which could be seen at a distance and which seemed to be occupying the entire left side of the abdomen. This mass had a smooth surface and a sharp

border which appeared to have many small notches. It was not tender. It appeared to move downward with inspiration and the examining hand could be passed between it and the costal margin. The remainder of the abdominal examination was essentially normal. Urine examination showed four hyaline casts and occasional mucous cylindroids per high power field. The blood showed 14.0 Gm. of hemoglobin per 100 cc. of whole blood, 4,900,000 red blood cells and 7,850 white blood cells per cubic millimeter, with a normal differential count. The color index was .95 and the red cells were normal in size and shape. A blood smear was negative for malaria and the icteric index was reported as 6 units. An intravenous pyelogram showed normal function in both kidneys with displacement upward of the left kidney and medially of the left ureter. The shadow of a large tumor could be seen containing a deposit of calcium measuring 8 by 13 cm. A gastrointestinal series showed the stomach to be pushed upward and to lie in an oblique position. The Jejunum was displaced into the right abdomen, the descending colon to the right, and the transverse colon upward, particularly at the splenic flexure.

On June 7, 1945, a laparotomy was performed using a left rectus incision and revealed a large retroperitoneal tumor located just to the left of the mid-line in the central portion of the abdomen. The descending colon was raised upon the surface of the tumor and displaced toward the mid-line. The mass extended through the entire left side of the abdomen from the pelvic region to the level of the spleen. It had a fibrous capsule which was adherent to the inferior vena cava and for this reason a portion could not be removed. The blood supply seemed to be derived from a number of rather small blood vessels off the external iliac artery and vein. The spleen was enlarged and there seemed to be a number of small, superficial calcifications over its surface. The re-

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FIG. 1. Flat plate (postero-anterior) of abdomen showing calcified tumor.



FIG. 2. Intravenous pyelogram showing tumor and renal pelvis deformity.

mainder of the abdominal organs were normal. The postoperative course was essentially uneventful.

Pathological examination showed an egg-shaped, shiny, hard mass having a grey color, a smooth surface and weighing 2,710 Gm. On section there was a densely calcified mass, roughly oval in outline and measuring 3 cm. at its greatest diameter. The cut surface showed shiny, whorled and white coarse bands of fibrous tissue. The microscopic section showed the specimen to consist of interlacing bands of fibrous tissue. The amount of collagen varied considerably and in the heaviest collagenized areas it was almost acellular. There were a few small foci of myxomatous degeneration but also many nests of actively proliferating fibroblasts. None of the latter were seen near the capsule. The sections which included the capsule showed it to be a heavily collagenized structure. Sections of the calcified area revealed merely calcium deposits on an acellular stroma.

We believe our case presents several interesting aspects. The relationship to trauma is of interest. The tumor was closely associated with an incident of trauma both in history and in location. It has been stated by Andrews⁵ that trauma is apparently not a factor in the cause of

retroperitoneal sarcoma. We have found no similar statement as to retroperitoneal fibroma but believe that our case may be considered as fulfilling the postulates of Segond.

Carson⁶ lists these criteria as, (1) the authenticity and adequacy of the trauma, (2) the previous integrity of the wounded part, (3) a reasonable time relation, from three weeks to three years or more in some cases, (4) continuity of the symptoms of the injury with those of the tumor, (5) microscopical or other proof of the existence and histological type of the tumor, and (6) location of the tumor at the point of injury. The previous integrity of the wounded part in our case can be inferred from the absence of symptoms prior to the injury. The location of the tumor at the point of injury is not as exact as in most cases cited in the discussion of this topic. These are unusual incidents involving extremities, which permit of more exact location than in the case of the chest or abdomen. The time relation is also considerably longer (sixteen years) than the limits given by Carson, but here again the abdominal location of the tumor com-

bined with its slow growth might explain the discrepancy. We realize the fallacy of drawing conclusions from only one case and that our observations may be based merely on coincidence, but due to the rarity of the lesion the rather definite association with trauma in our case would seem to make such observations worthy of mention.

Another aspect of interest is in relation to the differential diagnosis. Enlargement of the spleen is a frequent differential diagnosis with retroperitoneal tumors. The most frequently mentioned preoperative diagnosis in this case was splenomegaly of some type. The patient had been transferred to our institution with this diagnosis and gave the history of having been hospitalized for operation several years previously with decision against operation after consultation with numerous physicians. This latter might suggest that splenic tumor was considered at that time. In our preoperative examinations the left kidney was found by intravenous pyelogram to be displaced.

According to Wolfer² the left kidney is not displaced by splenic enlargement. However, Shulte and Emmett⁷ state that displacement of the kidney may be caused by a lesion of any intra-abdominal organ. One of their cases in point showed downward displacement and rotation of the left kidney resulting from an enlarged spleen. They also state that in 72.5 per cent of a general group of 112 cases of retroperitoneal tumor there was displacement of the kidney, ureter or both. Hence it would seem that while this sign of displacement of the kidney should be considered it cannot be depended upon as a final solution in the diagnosis as regards splenomegaly. Lesions of the gastrointestinal tract may be ruled out by x-ray with barium contrast medium. Other conditions that can be ruled out only by exploration are sarcomas, mesenteric or omental cysts, dermoids and teratomas.

As to the calcification of the tumor, we have found such a condition reported only



FIG. 3. Gastrointestinal series showing displacement and deformity of stomach and displacement of colon and small bowel to the right side.

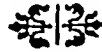
once previously in the literature, that being in the case reported by Fulton.³ There is some doubt, however, as to whether this may be as rare a condition as suggested, since some of the earlier cases were not subjected to a thorough pathological examination. Our case showed considerably more calcification than Fulton's. The process of calcification was probably due to degeneration of the tissues in the central portion of the tumor. The blood supply of the tumor was obviously inadequate and degeneration of the interior of the tumor as it continued to grow would seem to be inevitable. There was no evidence of a definite structure which would suggest a teratomatous lesion. The lesion was considered to be benign and the subsequent course has substantiated this.

SUMMARY

1. A case of retroperitoneal fibroma is presented.
2. Only thirteen previous cases are reported in the literature.
3. Points in the etiology, pathology and diagnosis of the case are discussed.

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LESIONS, abscesses, and tumors of the thoracic and abdominal cavities metastasize through the vertebral veins without involving the portal, pulmonary, or caval system (Batson).

From "Metastases Medical and Surgical" by Malford W. Thewlis (Charlotte Medical Press).

ARTERIOVENOUS ANEURYSM OR FISTULA

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THE incidence of arteriovenous fistulas following war wounds will probably increase and one should be prepared to recognize them and give the proper treatment. The simplest definition of an arteriovenous aneurysm is that it is a direct, unnatural communication between an artery and a vein usually due to trauma. The mechanism of the formation of such a communication is the simultaneous wounding (puncture) of the approximating artery and vein especially when enclosed in a common sheath without much disturbance of surrounding tissues and no extravasation. This type of aneurysm can readily result from shrapnel, bullet and similar wounds. Arteriovenous fistulas have also resulted from such surgical procedures as herniorrhaphies and tonsillectomies in which the surgeon's needle accidentally punctures two approximating vessels.

Two main types of arteriovenous aneurysms have been described with several varieties: (1) Aneurysmal varix which has no intervening sac. It is merely a plexus of veins forming a pulsating swelling that communicates with the artery. It is, therefore, not apt to rupture so easily; (2) varicose aneurysm in which there is a fibrous walled sac formed between the vessels which can gradually dilate and eventually rupture. There are several varieties of arteriovenous aneurysm, as illustrated in Figure 1.

The vessels most apt to be involved are the popliteal artery and vein, femoral artery and vein, internal carotid and internal jugular, brachial artery and median basilic vein; internal carotid and cavernous sinus, facial artery and vein, posterior tibial vessels and vessels of the orbit.

Symptoms and signs of arteriovenous aneurysm are: (1) Local swelling which

occurs in a few hours to a few days; it is soft, reducible and pulsating; (2) systolic thrill on palpation; (3) systolic bruit on auscultation; (4) dull, aching pain with various nerve disturbances, when the mass becomes large enough to exert pressure. Distal swelling of an extremity may also occur from a disturbance of the return circulation. (5) When the carotid and jugular vessels are involved or any branches in or near the skull, the bruit or murmur can become so loud and persistent as to interfere with sleep and rest.

DIFFERENTIAL DIAGNOSIS OF ARTERIO- VENOUS ANEURYSM

Highly vascular tumors or cysts of any type, as sarcomas and tumors of the carotid body, may resemble arteriovenous aneurysms. Location, presence or absence of a bruit, attempt at aspiration, history of trauma and possible biopsy may help in the differentiation. In taking a biopsy the possibility of an arteriovenous aneurysm must always be borne in mind.

Thyrotoxicosis is very often hard to differentiate when the lesion is in or near the skull (common carotid and cavernous sinus), producing a pulsating exophthalmos with an audible bruit. The basal metabolic rate and any history of injury to the skull may help to differentiate.

Simple Aneurysm must be differentiated for the following reason: Ligation of the artery proximal to an arteriovenous aneurysm will cause circulatory embarrassment and perhaps gangrene. The best test of differentiation is by digital compression:

Compression of the artery proximal to the aneurysmal mass in an arteriovenous aneurysm will produce a systolic thrill and bruit, prominence of the veins in the region of the fistula, slowing of the pulse and

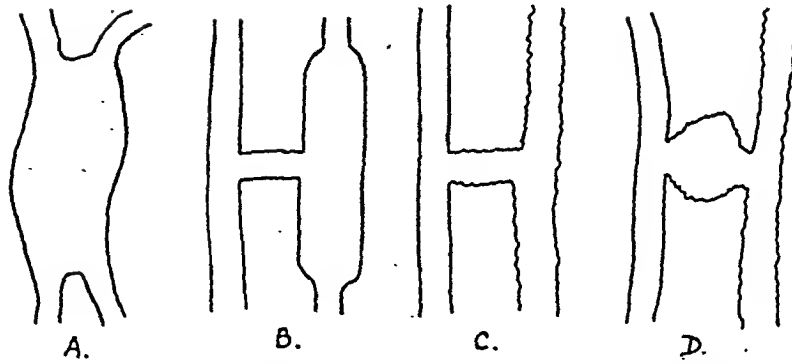


FIG. 1. Diagrammatic illustrations of varieties of arteriovenous aneurysms; A, direct communication; B, aneurysmal varix; C, small fibrous opening communication; D, varicose aneurysm.

increase in the blood pressure. Compression of the artery proximal to a simple aneurysm produces no effect on pulse or blood pressure.

TREATMENT OF ARTERIOVENOUS ANEURYSM

There is no tendency to spontaneous cure of an arteriovenous aneurysm. If left untreated, the larger ones may rupture or result in cardiac hypertrophy due to the increased volume of blood thrown on the heart. Surgery is the only method of treatment.

If the lesion can be approached the artery and vein are ligated proximal and distal to the false opening. After the ligation of these vessels, proximally and distally, the entire mass may be excised *en masse* and the wound sutured.

If the lesion cannot be approached, as in the base of the skull, etc. the afferent artery is ligated (subject to the risk of cerebral ischemia) in the hope that the diminution in the blood current relieves the symptoms. At times this is not advisable and the best that can be done is exposure of the area and tamponade.

CASE REPORT

A patient was admitted to the hospital with a painful, pulsating mass in the left ankle, numbness in the first and second toes of the left foot and slight swelling of the left foot and ankle. The past history was essentially negative except for the injury leading to the present illness.

The present illness began eight months previ-

ous to admission. While cutting some high grass with a machete, it slipped and cut him on the inner aspect of the lower left leg near the ankle joint. He was taken to a hospital where the wound was sutured and it healed without trouble. About eight months later he began suffering from throbbing and aching pain in the area of the wound and noted that the first and second toes of the left foot felt numb with slight swelling of the left foot and ankle. The condition became progressively worse and three weeks later he reported to the dispensary of the hospital where he was admitted.

Physical examination revealed a pulsating, tender mass on the medial aspect of the left ankle just above the ankle joint. Compression applied digitally just above the mass produced a systolic thrill and bruit. We knew we were dealing with an arteriovenous aneurysm. Further check-up disclosed a slight rise in blood pressure and decrease in pulse rate as the digital compression was maintained.

Operation was performed several days later. Excision of an arteriovenous aneurysm of the posterior tibial artery and vein was done. The artery and vein proximal and distal to the pulsating mass were ligated, the mass freed and removed *en masse*, all bleeding controlled and the wound sutured. Healing took place by primary union and the patient was discharged from the hospital entirely free of symptoms.

CONCLUSION

A case of arteriovenous aneurysm of the posterior tibial artery and vein has been presented with the surgical treatment instituted. One should bear the condition in mind especially in men returned to civilian life with old war wounds.

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A TENSE anal haematoma, resulting from rupture of one of the anal veins, commonly occurs on the lateral aspects of the anal margin, and it is in this situation that excision of the swelling is most suitably carried out. The operation should be done when the haematoma is single and tense, before the overlying skin has become ulcerated and before the clot has discharged with risk of local infection.

From "Minor Surgery" edited by Humphry Rolleston and Alan Monerieff (Philosophical Library).

LYMPHOSARCOMA OF THE RECTUM*

FIVE-YEAR CURE FOLLOWING LOCAL REMOVAL

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THE purpose of this case report is to present a five-year cure of a rectal lymphosarcoma which was treated only by local excision and fulguration rather than by more radical surgery.

The generally accepted treatment of rectal lymphosarcoma has been radical surgical excision of the rectum when possible, followed by radiation, or radiation alone in inoperable cases. Hayes, Burr, and Pruitt,¹ in 1940, stated: "... regarding lymphosarcoma, all are agreed that metastases occur early and that the only hope of a cure is early radical removal, followed by irradiation." Rankin and Chumley² reported the results of fifteen resections for lymphosarcoma of the rectum and colon with four operative deaths, five with known recurrence at the time of writing, and an average length of life of eleven and a half months. One patient lived one year and another four years without recurrence. Tuta and Rosi³ reported a case in 1942 in which the patient was treated with local wide excision followed by irradiation. There is no follow-up report as yet. T. E. Smith,⁴ in 1943, reported a case simulating an internal hemorrhoid which was removed and then treated with irradiation. In 1943, Rosser⁵ stated that there was no agreement at that time as to the proper management of lymphoid tumors of the bowel. N. D. Smith⁶ summarized the treatment of such tumors by stating that it can be divided into three types: symptomatic, surgical and that by radiation, and usually two or three types are combined. He adds that surgical treatment of the part has pro-

duced some apparent cures, and radium and roentgen rays have produced some very striking results.

The following patient was treated by local snare excision with fulguration:

CASE REPORT

M. H., a thirty-five year old white female, began to have diarrhea in the latter part of November, 1940. It consisted of three to five soft stools daily with some sharp rectal pain occurring momentarily with each defecation. There were also several episodes of tenesmus. This continued for eight days, and during the latter two days of this period she had two to three bowel movements daily with thick yellow mucus and some small dark red clots, and one to two light brown stools. On November 30, 1940, she was examined and a small polyp, about 1 cm. in diameter with 5 mm. base, was seen on the posterior rectal wall, just inside the internal sphincter. This was removed with the diathermy snare and completely fulgurated at the base with diathermy. The tumor was examined by Dr. G. Y. Rusk, pathologist at Mt. Zion Hospital at that time, who reported: "Microscopic examination of polypoid mass from rectum shows the epithelium and mucous membrane normal. In the submucosa and subjacent tissues are a number of variably sized clusters of small mononuclear cells, lymphocytic in type. Some of the cells show less densely chromatic staining than typical lymphocytes. Cells in mitotic division are present in moderate numbers. The growth invades the deeper structures and through strands of connective tissue. Differential staining for reticulum fails to disclose argyrophilic fibrils related to the tumor cells. Diagnosis: Lymphosarcoma." (Fig. 1.)

Examination of the operated area two weeks later revealed a small crater-like depression on

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the posterior wall, just inside the anal canal. Hospitalization was again recommended for more complete study.

Physical examination on admission to the hospital was not remarkable. Except for a few small palpable anterior cervical lymph nodes and slightly enlarged bilateral inguinal lymph nodes, there was no lymphadenopathy. Blood count: hemoglobin 12.7 Gm., 82.7 per cent; white blood cells 12,100; polymorphonuclears 66; monocytes 4, lymphocytes 30; filamented 79 per cent; coagulation time 3; bleeding time 3; urine—trace of albumin, seven to eight white blood cells per high power, five to six red blood cells; serology—negative.

Sigmoidoscopy disclosed posteriorly, just inside the internal sphincter, a shallow granulating ulcer at the site of the removed polyp. The base appeared healthy. Barium enema showed multiple diverticula of the descending colon; otherwise it was normal. On December 21, 1940, another biopsy was taken from the fulgurated area. This showed no evidence of the tumor noted in the previous biopsy. She was discharged to the out-patient department on December 23, 1940, for follow-up. On January 7, 1941, it seemed that there was some change in the operated area, and it was decided to readmit her to the hospital for further consideration and possible radical surgery. Her case was discussed at Grand Surgical Rounds, where a variety of opinions were expressed by different surgeons as to how she should be treated. It was decided finally to give no other treatment and observe her carefully in the out-patient department. On January 14, 1941, she was discharged and followed in the out-patient department at intervals of three to four months until June 15, 1943. At that time she felt well, had no rectal complaints, and there was no palpable or visible signs of recurrence. The patient has been seen at intervals since then, the last time in November, 1945, at which time the findings continued to remain negative and she was in good health.

There is some confusion among pathologists as to the exact nature of this disease. The lymphocytic type of lymphosarcoma is a true neoplasm, infiltrative and destructive. Kundrat⁷ believed that it originates in a single site and then extends along the lymphatic system, forming diffuse infiltrations more or less distant from

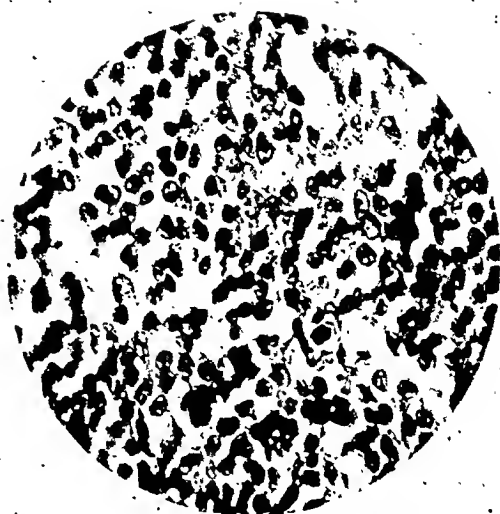


FIG. 1. Microphotograph of section of rectal lymphosarcoma. The tumor is composed of a solid sheet of small lymphocytes enmeshed by a fine fibrous stroma. Two mitotic figures are readily noted. The stroma does not contain argyrophilic fibrils. $\times 600$.

the original site. There is no question, however, as to whether every lymphocytoma which appears to be invasive and to show mitotic figures is clinically equally malignant. Whether the term "benign lymphoma," as mentioned by Boyd,⁸ is acceptable or not, there appear to be localized lymphocytic tumors which may be encountered in the bowel and which are not clinically malignant, although in microscopic appearance they are identical in many respects with the clinically malignant type of lymphosarcoma. Ewing⁹ calls lymphosarcoma of the rectum a malignant lymphocytoma. The question is raised: Is there a benign lymphocytoma of the rectum? Our case would seem to belong in this category. The fact that this growth was small, polypoid, single and unassociated with any symptoms of systemic involvement, led to the decision to treat it conservatively and thus avoid the risk and consequences attending radical surgery. Continued, careful observation for a period of five years has disclosed no evidence of recurrence. We believe we are justified in concluding that an occasional rectal polyp which proves to be histologi-

cally lymphocytoma may also prove to be clinically benign and can be treated successfully by local conservative surgery.

SUMMARY

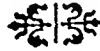
A case of lymphosarcoma in a rectal polyp is presented. Treatment consisted only of local removal with the diathermy snare and fulguration of the base. There is no evidence of recurrence after five years.

It is suggested that lymphosarcoma of the lymphocytic type, when occurring in a polyp and unassociated with any evidence of involvement of the general lymphatic system, may be clinically not malignant, or of such a low grade of malignancy as to permit successful treatment by thorough

local removal and continued careful observation.

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TOTAL RESECTION OF THE CLAVICLE

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THE total resection of the clavicle is a rare surgical procedure and the information in the literature concerning it is exceedingly scanty.

Gurd¹ resected the entire clavicle in a young girl in 1912. Cohn² resected the clavicle in a young man suffering from a pathological fracture, due to a metastatic malignancy in 1926. Gurd³ has reported three cases in which he has resected the outer half of the clavicle for severe acromioclavicular displacements and has done several complete resections since the aforementioned report.

During the past two years I have performed a total resection of the clavicle in two cases and since the procedure has yielded such satisfactory results, it is deemed advisable to focus more attention upon its merit.

CASE REPORTS

CASE I. B. K., a fifty-two year old, white, male was admitted to Touro Infirmary on May 6, 1944, with a complaint of pain in the left shoulder of three weeks' duration. X-ray examination revealed a pathological fracture at the junction of the middle and distal third of the left clavicle. The left clavicle was resected *in toto* on May 12, 1944, and a Desault dressing applied. The specimen revealed a metastatic adenocarcinoma of the clear cell type. He was up walking about the ward on May 14, 1944, and did not complain of pain. Subsequent work-up of the patient revealed a hypernephroma.

Comment. The clavicle was resected in preference to doing a biopsy. If merely a biopsy had been done, the patient would have continued to have pain. After one week all immobilization dressings were discarded. There was no resulting deformity and all motions were present.

CASE II. E. A., a thirty year old, white male was admitted to Touro Infirmary on February 18, 1945, for a severe comminuted fracture of the left clavicle that had been incurred several hours before. It was my intention to do an open reduction at operation on February 19, 1945. However, at operation, it was found out there were four large comminuted fragments that were razor sharp and required removal. After removal of the fragments it was impossible to bridge the resulting large defect with wire or a plate. I then decided that the only recourse was to resect the clavicle. A Desault dressing was applied. The patient was ambulatory the next day and discharged on February 21, 1945.

Comment. The patient was immobilized for one week and returned to work as a policeman in three weeks. There was no resulting deformity nor any limitation of motion. I had treated this patient three years previously, by conservative methods, for a fracture of the right clavicle. He stated that he preferred his second experience over the first, for he did not have as much discomfort, nor as long a period of disability. Of course, this is mentioned only to illustrate that the total resection of the clavicle is not a shocking procedure.

The clavicle is a slender, flat, doubly curved bone which articulates with the sternum medially and its outer extremity articulates with the acromion of the scapula. It is attached to the coracoid process by the coracoclavicular ligaments. The function of the clavicle has been described as a prop to hold the shoulder outward and backward from the trunk and to support the scapula. This is not true. Weinstein³ dissected a cadaver with bilateral congenital absence of the clavicles and inquired into the patient's past to know if she had lead a normal life or had been handicapped. She was normal in

every way according to acquaintances. Gurd⁴ states, "The clavicle does not act as a strut nor does it support the shoulder. That these statements are true is proven, I believe, by the fact that complete removal of the clavicle is not followed by either shortening of the distance from the tip of the shoulder to the midline of the body, nor by dropping of the shoulder on the affected side." My experience confirms this observation. It is amazing to see these patients use an extremity so freely just two weeks after operation. One then asks the question, "What is the function of the clavicle?" Gurd⁵ states, "He is more than ever, convinced that, apart from its function in serving for the attachment of muscles, this bone serves no useful purpose."

It is not intended that all fractures of the clavicle be treated so radically nor that resection of the clavicle has frequent indications. It is a procedure of definite value in the armamentarium of bone surgeons and is indicated in pathological fractures of the clavicle, severe acromioclavicular displacements, severe commin-

uted fractures of the clavicle with loss of substance, and possibly to afford a better exposure in operating structures deep in the chest.

CONCLUSION

1. Total resection of the clavicle is not a shocking operation and has a relatively short period of disability.
2. It is not followed by deformity or loss of function.
3. The principal function of the clavicle is to act as a muscle support.
4. Resection of the clavicle is indicated in pathological fractures of the clavicle, severe acromioclavicular separations, severe comminuted fractures of the clavicle with loss of substance, and possibly to afford better exposure to thoracic structures.

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ABERRANT PANCREATIC TISSUE IN THE GALLBLADDER WALL

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REVIEW of the available literature shows numerous reports of the presence of aberrant pancreatic tissue in the gastrointestinal tract but relatively few reports of pancreatic tissue in the gallbladder. Faust and Mudgett¹ review the literature describing aberrant pancreatic tissue in general, with the report of one case, and mention two cases in which the gallbladder was involved.

CASE REPORT

Mrs. R. R., a white female, housewife, aged forty, first reported for examination because of abdominal pain with intermittent cramps radiating to the left shoulder and the left arm. Pain of this nature, of moderate severity, had been present intermittently for ten days. The onset was rather sudden and not related to any particular activity or food. There was some nausea and occasional emesis of bile-stained fluid. No history of similar previous disturbances or of gastrointestinal complaint was elicited, although the patient avoided greasy or fatty foods because of the formation of "gas" and abdominal distention.

Her father and mother had died of diabetes. Seven brothers and one sister were living; one sister had diabetes. The patient had two children living and well. In 1927, the patient was operated upon and both tubes, ovaries and appendix were removed.

Physical examination revealed a well nourished individual weighing 140 pounds. Her skin was clear and pink; the head, nose and throat revealed nothing abnormal; the chest was symmetrical; there was limited excursion of the chest wall on inspiration due to pain in the right and left upper quadrants; the lungs were clear on percussion and auscultation. The heart was normal in position and size; the heart sounds were clear, distinct and regular. Blood pressure was 144/88, temperature 99°F. The abdomen was rounded and had a thick wall of subcutaneous fat; there was definite muscle



FIG. 1. Microphotograph of section of gallbladder wall, low power.

rigidity of the right rectus muscle above and below the level of the umbilicus. There was diffuse tenderness over the entire abdomen, more marked over the right epigastrium. Above the level of the umbilicus on the right, a definite soft tumor mass moderately tender, could be palpated. There was noticeable tenderness on percussion over the right kidney region. The examination otherwise showed nothing abnormal.

The genitourinary tract examination revealed nothing abnormal. An electrocardiographic tracing was normal.

Laboratory findings revealed red blood cells 4,000,000; white blood cells 7,700; polymorphonuclears 78; lymphocytes 21; basophiles 1; sedimentation rate normal; urine occasional red and white blood cells; Kahn negative; non-protein nitrogen 33 mg; sugar 129; chlorides 470; icteric index 9.2.

The patient was operated upon August 15, 1944. The usual skin preparation and draping was carried out; an upper right rectus incision was made. Moderate bleeding occurred with good hemostasis. On opening the peritoneum, no free fluid was found; the right liver lobe extended about three fingers below

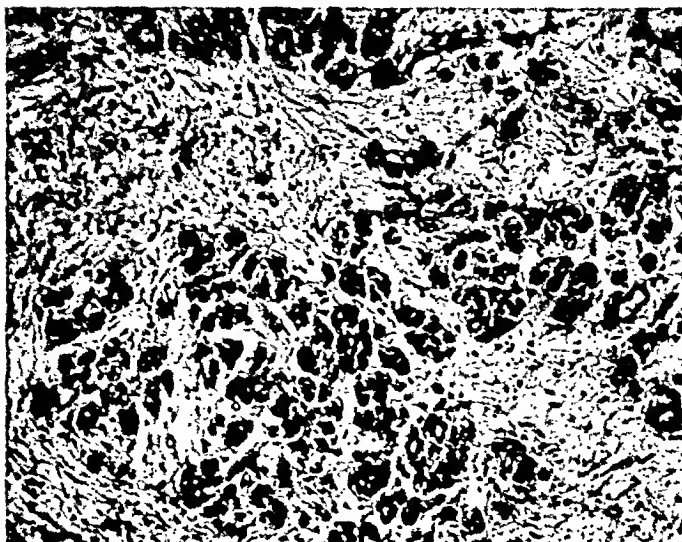


FIG. 2. Microphotograph of section of gallbladder wall, high power.

the costal margin, sharp-edged, with several streaks of white areas throughout the visible lobe of the liver. The gallbladder was greatly enlarged, greenish-gray in color, thick-walled and tense. Several large glands could be felt at the junction of the cystic and common ducts. No stones were palpable in the region of the cystic or common duct. The contents of the gallbladder removed from below upward; the cystic duct and cystic artery were ligated separately. The gallbladder bed was approximated with a running plain catgut suture. Search for the appendix revealed none, but a number of thick, old adhesions were found in the right pelvic area. The pancreas was not thickened or hard. The abdomen was closed in layers with one rubber tissue drain leading down to the cystic duct. Chromic catgut was used throughout. The postoperative condition was good. The gallbladder, opened after removal, was found to be thick-walled, edematous, with a rough, thickened mucosa. Several small sand-like calculi were found.

On August 29, 1944, following the complaint of increasing pain in the right flank and the appearance of fullness in this region, a stab wound was made to the right of the previous operative incision and about 4 ounces of bile-stained fluid was removed. Following this, the patient recovered speedily and was discharged on September 19th.

The pathological examination report was as follows: (Gross) The gallbladder measures 8 by 4 by 2 cm. The neck of the gallbladder apparently had been incised before fixation. The serosal surface is yellowish-gray, mottled with hemorrhage. There are numerous fibrous

tags over the entire surface. On section, the wall is markedly thickened, measuring from 3 to 6 mm. in thickness. The cut surface of the wall is yellowish-gray, mottled with hemorrhage. The lining mucosa appears to be ragged and brown. The gallbladder is empty and collapsed except for one round gallstone measuring 4 mm. in diameter.

Microscopic: The mucosa of the gallbladder is largely flattened and the folds are not prominent. The epithelium is well preserved. Abundant round cell infiltration prevades the tunica propria and the muscularis. Moderate amounts of hemorrhage are present in some portions. The adventitial coat is very greatly thickened. In some sections, there are some well differentiated islands of pancreatic tissue, complete with small ducts, islands of Langerhans and typical acini. These portions of pancreas show considerable interstitial fibrosis.

Diagnosis: (1) Chronic cholecystitis, with cholelithiasis; (2) aberrant pancreatic tissue.

I wish to thank Major Lester S. King, M.C. Pathologist at the William Beaumont General Hospital, El Paso, Texas, for his pathological report.

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TRAUMA TO THE SESAMOID BONES OF THE THUMB

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INJURY to the sesamoid bone of the hand may produce marked disability and produce a clinical entity, the true nature of which is frequently overlooked. The sesamoid bones of the hand are two very small nodules which lie in the tendons of insertion of the flexor pollicis brevis and abductor pollicis. They are blended with the palmar ligament of the metacarpophalangeal joint and play against the palmar surface of the head of the metacarpal bone. Because of their anatomical position they are subjected to certain trauma, both direct and indirect and cause a very painful condition in the hand. As they lie in the tendon to the thumb and over the head of metacarpal number one, any force applied to that area, either acutely directed or by intermittent occupational irritation, may be the cause of inflammation of these bones, a condition which is not always thought of.

The two cases reported here came to my attention within one month and show injury to these bones, one by direct force and the other as a result of chronic occupational irritation.

CASE REPORTS

CASE I. A. G., a male, thirty-five years of age, gave no history of previous accident to either hand. The patient stated that on June 1, 1945, while drilling a piece of bronze, the drill got stuck in the hole and the piece of material was whirled around and hit the palmar surface of the left hand over the first metacarpophalangeal articulation. There was considerable pain and swelling over the site of injury. Pain continued and was accentuated each time anything was grasped by the hand or if any pressure was made directly over the injured part of the hand. X-ray of the bones of the thumb in anteroposterior, lateral and oblique

planes was negative for bone or joint disorder. Examination of the hand revealed neither limitation of motion nor any acquired or congenital deformities of the fingers. There were no swellings nor any signs of inflammation. The first metacarpal bone examined by dorsal and palmar routes showed no tenderness nor swelling along the entire length. There was point tenderness on the palmar surface over the distal head of metacarpal number one. This could be elicited by direct pressure which was more acute if the tendon and sesamoid were grasped between the examining index finger and thumb.

This patient was admitted to the hospital and operated upon. Under pentothal sodium anesthesia, with tourniquet applied, an incision was made on the palmar surface of the hand, just below the crease of the metacarpophalangeal articulation of the thumb. The incision was through skin only; all other deeper dissection was done in the plane of the tendons and other important structures. The tendons were retracted; the sesamoid bone was exposed and removed. The deeper structures were reconstructed with No. 000 plain catgut. The skin was brought together with black silk. A pressure dressing was applied and the hand immobilized. The usual two weeks' immobilization followed, and then active and passive motion with hot soaks was started.

The pathological report follows: *Gross:* The specimen consists of irregular piece of tissue 1.7 by 0.5 cm. One portion is grayish white and calcified. The adjacent portion is pinkish gray, pliable and soft. *Microscopic:* One portion of the tissue is composed of trabeculae of cancellous bone. Compact fibrous tissue is attached to the margins. There is moderate hyalinization.

CASE II. L. C. a female, forty-seven years of age, had had no previous injury to her hands. Her work consisted of holding a piece of work in her left hand and putting insulation into this structure. It was necessary to grasp the apparatus tightly in her left hand and exert considerable pressure with the right hand.

* From the Hand Clinic, St. John's Hospital, Brooklyn, N. Y.

After five months at this work she complained of pain in the palm of the left hand over the base of thumb at the metacarpophalangeal articulation.

X-rays taken in the three planes were negative. Examination of the hand showed no arthritic changes, no acquired nor congenital deformities, no swellings nor signs of inflammation and no loss of motion of any of the fingers. The only positive finding was tenderness over the sesamoid bones, elicited by direct pressure and also by lateral pressure, using the examining index finger and thumb.

This case was admitted to the hospital for operation and the same procedure was followed as on the previous case.

The pathological report follows: *Gross:* The specimen consists of a piece of bone 0.4 cm. in diameter which is irregular and covered by a scant amount of reddish gray fibrous and muscular tissue. *Microscopic:* The specimen is composed of coarse trabeculae bone with scattered irregular marrow spaces. Osteocytes are poorly defined. Dense, caliginous fibrous tissue is fused with the margins. There is a focal osteoblastic activity. Fibroblasts of ovoid and fusiform types are scattered through the interstices.

On January 10, 1946, final follow-up of these cases showed both of them to be symptom free. There was no pain, nor disability and they had returned to their usual work.



AMPUTATION at the wrist should be planned, if possible, so as to save the thumb and a finger or other portion of the hand against which the thumb may be apposed. *Amputation at the wrist* prevents the proper fitting of an artificial hand and wrist mechanism without undue length, and *should be avoided*.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

POST-PARTUM, BILATERAL CORTICAL NECROSIS OF THE KIDNEYS WITH RECOVERY*

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AUGUSTA, GEORGIA

BILATERAL cortical necrosis of the kidneys is a rather rare disease, 70 per cent of the cases reported being a complication associated with the termination of pregnancy, the remaining 30 per cent followed a variety of infections or toxic conditions. The disease is usually fatal. Madding et al.¹ reviewed the literature in 1940, finding seventy-four cases reported and added one case. Of these seventy-five cases (fifty-three pregnant) only twelve recovered, a mortality of 84 per cent, and only one gave birth to a live fetus (twins).¹ We believe that our case is unusual in that the patient recovered, though she almost succumbed; secondly, because she gave birth to twins, still living, which is singular, since the only other case in which the fetus was alive at birth was a twin pregnancy. Since recovery is rare one feels justified in reporting this case to show the degree of recovery after a year. Fortunately, we do not have autopsy findings to verify the diagnosis, but the clinical course was most characteristic of those cases reported.

The onset of this disease is characterized by a sudden total anuria or severe oliguria with the passing of scanty amounts of bloody urine at the time of delivery or shortly thereafter. The delivery of a still-born between fifth and eighth month is most frequent.² Retroplacental hemorrhage or severe hemorrhage at time of delivery seems characteristic. Shriver found fourteen of thirty-three cases to be complicated by retroplacental hemorrhage,³ and Stening's case began with a severe accidental hemorrhage and pre-

mature delivery.⁴ The case reported from the Mayo Clinic occurred after delivery of a dead fetus associated with severe hemorrhage requiring transfusion.¹ No particular symptoms are noted, prior to delivery, although some of the patients had headache, edema and some signs of toxemia. The course is one of continued anuria or oliguria with azotemia, simulating an obstructive anuria, except that there is little or no renal tenderness. Blood pressure is usually not elevated but may increase during the course of the disease. Edema may not be present or may appear gradually and be associated with convulsions of the eclamptic type. Hiccough and uremic convulsions are terminal developments.

Ricker ascribes the changes in the kidney to vascular irritability leading to vasoconstriction of the proximal segments of the renal arteries with dilatation of the terminal arterioles and capillaries which is followed by thrombosis, exudation, hemorrhage, infiltration and necrosis of the renal cortex.³ While the exact pathogenesis of the process is not known, most writers subscribe to Oertel's concept that the disease is an angioneurotic anuria and "if circulation is reestablished and stasis relieved, corpustular conglutination is dissolved and offers no obstruction to renewed flow"² which would make recovery possible.

CASE REPORT

Mrs. S., aged thirty-two, white, the wife of a physician, primipara at seven and one-half months, came to the University Hospital,

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July 29, 1944. She was in labor with the diagnosis of a twin pregnancy. The antepartum course had not been remarkable. The cervix was dilated on admission and soon after a female was delivered by breech extraction by one of us (J. W. T.) followed by a second delivery of a female by low forceps. Both babies were small but appeared to be in good condition. Delivery was followed by hemorrhage and reduction of hemoglobin to 6 Gm. Her blood was type IV, Rh positive. A transfusion of 500 cc. of citrated blood which was compatible on cross match was given. Blood pressure was 110/80 and there was no reaction during the transfusion or any symptoms that would suggest that the blood was incompatible.

She was catheterized two hours later and 300 cc. of dark urine were obtained but not examined. She had not voided by the next morning and was catheterized; 4 cc. of thick dark brown urine were obtained. The second morning 20 cc. were obtained by catheter, dark in color and contained many red blood cells and white blood cells. Urological consultation was requested. At this time her hemoglobin was 7½ gni., red blood cells, 2,450,000, white blood cells 11,850; non-protein-nitrogen 74 mg. per 100 cc. of blood. The usual therapeutic measures were administered; intravenous fluids, aminophyllin, alkalies, etc., without apparent benefit. The splancnics were injected with novocaine by the neurosurgeon, Dr. W. A. Risteen, and in the next twelve hours 50 cc. of urine were excreted. The next twelve hours she was not catheterized. On the third day of the anuria her non-protein nitrogen was 90 mg., blood chloride 525 mg., serum protein 4.01 per cent. Cystoscopy and ureteral catheterization were done to rule out local disorder or obstruction and were negative.

The fourth day 25 cc. of urine were obtained. Clinically, her condition was much worse, her blood pressure rising to 148/90 with some edema. On the fifth day the non-protein nitrogen was 64 gm., blood pressure 162/100. Edema had become marked and she appeared to be moribund. Her pulse was 130 and was of poor volume; prior to this date it had not been above 90 and had been of good quality. She began to have eclamptic type of convulsions in rapid succession which were controlled with magnesium sulfate and followed by coma; up to this time she had been in good contact, had no complaint of pain and was still afebrile.

On the sixth day 600 cc. of urine were obtained by catheter; later she voided 200 cc.; blood pressure was 138/80; non-protein nitrogen 72 mg. She still looked very ill. On the seventh day she voided 1,250 cc. of pale urine which contained a moderate number of pus cells; blood pressure was 160/88; pulse 105; 500 cc. of plasma were given. On the eighth day she voided 1,450 cc., blood pressure was 160/90 non-protein nitrogen 81 mg., carbon dioxide 56 per cent. On the ninth day, blood pressure was 142/80 non-protein nitrogen 72 mg., blood chlorides 388 mg. On the tenth day blood pressure was 130/70 non-protein nitrogen 81 mg. On the thirteenth, fifteenth and eighteenth days the nonprotein nitrogen was 54 mg., 47 mg. and 36 mg., respectively.

On the twenty-fifth day she was discharged much improved, her blood pressure was 120/80. The urine contained many white blood cells. Mosenthal test: The day urine totalled 1,170 cc., specific gravity ranging from 1.007 to 1.014. The night urine totalled 470 cc., specific gravity, 1.014. P.S.P. (I.V.) 10 per cent first hour; 10 per cent second hour, total 20 per cent in two hours, hemoglobin 9.1 Gm. She was given mandelic acid therapy for *Bacillus coli* in the urine, probably the result of catheterization and told to return in a month.

She was seen again on September 24, 1944. The urine specific gravity was 1.000 and negative; non-protein nitrogen 19 mg.; white blood count 7,600; hemoglobin 11 Gm. Mosenthal test: Day specimen 1,040 cc.; specific gravity ranging from 1.006 to 1.014; night urine: 450 cc.; specific gravity 1.016, P.S.P. (I.V.) first half hour 15 per cent; second half hour 15 per cent; second hour 5 per cent; total 35 per cent in two hours.

On November 13, 1944, she was feeling well. Her blood pressure was 120/70; urine specific gravity 1.007 and negative; hemoglobin 10 Gm.; non-protein nitrogen 24 mg., P.S.P. (I.V.) 15 per cent first half hour, 25 per cent second half hour, and 10 per cent second hour; total 50 per cent in two hours. I.V. urogram was normal. Mosenthal test: 990 cc. day urine; specific gravity ranged from 1.004 to 1.024; night urine 300 cc.; specific gravity 1.023.

On March 12, 1945, she was in a satisfactory condition. Her blood pressure was 110/70; urine specific gravity was 1.008 and negative; hemoglobin 12.25 Gm.; P.S.P. (I.V.) first half

hour thirty per cent; second half hour 15 per cent; second hour 10 per cent, total 55 per cent in two hours. Mosenthal test: day urine 865 cc.; specific gravity ranging from 1.007 to 1.024; night urine, 160 cc.; specific gravity 1.033. The twin daughters were doing well.

COMMENT

A case is presented in which the clinical history and course is quite typical of bilateral cortical thrombosis, following a premature delivery associated with hemorrhage. The following facts aid in differentiating this case from a transfusion reaction: The blood which the patient received was typed and cross matched by a competent technician, the patient was Rh. positive which would preclude difficulty due to the Rh. factor. There was no evidence of a reaction from the transfusion or jaundice following. The urine contained red blood cells and was a hematuria, not a hemoglobinuria from the onset.

No casts were found and albumin in the urine ranged from three plus to a trace, but it seemed that most of the albumin could be accounted for by blood or pus cells present. While the response

from the splanchnic block was not dramatic it is difficult to evaluate in this case. In view of Oertel's concept it would seem to be a rational therapeutic procedure as it should relax the proximal renal arteries and aid in reestablishing circulation in the terminal arterioles and capillaries, particularly if done early in the course of the disease. Early reestablishment of circulation should spare some areas of the cortex and diminish the total area of necrosis. Fluids, acid base balance and supportive treatment are essential. From the follow-up study of this case one would conclude that there is a gradual improvement with return of normal kidney function over the period of a year.

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The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-fifth Year of Continuous Publication

VOL. LXXII

SEPTEMBER, 1946

NUMBER THREE

Editorial

SURGERY IN WORLD WAR II

THE entrance of our country into a war of the extent of the recent conflict necessarily meant the marshalling of all our resources in order to bring the war to an early and successful conclusion. One of these resources was the medical profession, and not the least part of the profession consisted in those trained in surgery. The Medical Departments of the Army and Navy early recognized that they would need the services of thousands of men then in civilian practice. It was very fortunate that during the period between World War I and World War II, the advantages of and even the necessity for adequate training in surgery were recognized and encouraged.

Trained surgeons of all ages were in the armed services, and to this probably more than to anything else can be attributed the extraordinarily good results that were obtained in the treatment of war casualties. The value of trained personnel was never more apparent than in the military services. There were difficulties to be overcome, and one of these was the problem of rank; older or less well trained men with higher rank occasionally were, of necessity, called upon to work with younger men of more recent training. This difficulty was usually

submerged in the general effort to accomplish the task to be done.

Only in a war of the magnitude of World War II is there an opportunity to study certain groups of cases on a large scale. The services are to be congratulated in their effort to segregate the various types of cases and to place them in charge of men whose interest and training made them of special value in the care of these patients. Not only were the patients able to receive more adequate care, but through the interest and diligence of many of the men caring for them, research problems were solved which will be valuable in civil life as well as in military surgery. The Medical Departments of the Army and Navy appreciated the value and necessity of selecting trained or promising young men and of giving them an opportunity to carry out research problems, even in the field.

In this review of war surgery, an effort has been made to cover fairly widely the field of surgery. Many of the papers are written by younger men, and all of them are first-hand accounts of actual work performed. Almost all the fields of combat are represented in this group, and the papers presented reflect experiences under various types of combat or continental positions. Each has to do with some form

of trauma or its treatment. No effort has been made to include in this symposium a review of other surgical conditions which arise as complications of diseases incidental to the war, such as those associated with malaria or amebiasis.

The editor wishes to thank the contributors to this symposium and to congratulate the publishers on their willingness to bring together a Review of War Surgery.

L. KRAEER FERGUSON, M.D.



EVERY severely wounded person is shocked, especially if there is accompanying soft tissue damage and hemorrhage such as occurs with compound fractures. Shock should be anticipated and prevented as much as possible. When the patient is severely shocked, the general treatment must have precedence over local treatment.

From "Fractures and Dislocations for Practitioners" by Edwin O. Geckeler (The Williams & Wilkins Company).

Original Articles

THE SHOCK OF BATTLE WOUNDS

A REVIEW OF THE TREATMENT IN 2,000 CASUALTIES

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DURING the first eight months of the campaign through France and Belgium, 10,700 wounded soldiers were operated upon in the 2nd Evacuation Hospital. More than 2,000 of these patients were treated for shock. This paper is a review of some phases of their preoperative treatment.

METHOD OF STUDY

Chart 1 is a sample of the chart completed on every patient who was admitted to the shock ward. Observations were made and recorded at least every thirty minutes. The chart accompanied the patient to the operating room where the anesthetist regularly recorded blood pressure, pulse and fluid intake, and to the ward where additional data could be added.

When the patient was discharged, the shock chart was extracted from the jacket and returned to us; subsequently our records on each shock chart were completed from retained clinical records by making an abstract of the patient's condition, course, operative findings and disposition.

An autopsy was performed upon all of the 251 patients who died, and the findings were added to the shock record.

Table 1 indicates the number of admissions the shock ward received each month. The patients have been classified according to the anatomical regions primarily involved. Although the majority of battle casualties suffer from multiple wounds, each patient has been listed only once, and

under that region which encompassed his most severe injury.

CLASSIFICATION OF ADMISSIONS TO THE SHOCK WARD

It will be seen from Table 1 that the first subdivision is that of mild shock and severe shock. This subdivision is necessary because the treatment and results are widely different in the two groups. For statistical purposes, the patient was considered to be in severe shock if upon admission his blood pressure was below 100 systolic. If his blood pressure was above 100 systolic, he was considered to be in mild or compensated shock. It is recognized that impending circulatory failure due to a reduction of the effective blood volume is frequently masked by a compensatory vasoconstriction which maintains the blood pressure at a normal level despite the loss of a significant volume of blood.¹ Clinical judgment in appraising the true condition of a patient must, therefore, be influenced by other factors such as the severity of the wound, the probable amount of blood lost and by his general appearance and reactions. It would be a grave mistake to rely solely on the blood pressure in establishing the diagnosis of shock, and to treat only those patients in whom the compensatory mechanism has already failed. The subdivision of shock cases into mild and severe shock has been disregarded in the case of burns. As the location of the burns often rendered

TABLE I

NUMBER OF ADMISSIONS THE SHOCK WARD RECEIVED EACH MONTH
(Admissions have been classified according to the anatomical region primarily involved)

	July	Aug.	Sept.*	Oct.	Nov.	Dec.	Jan.	Feb.	Total
Mild Shock									
Brain.....	6	2		16	13	11	10	11	69
Maxillofacial.....	11	3		14	19	4	13	9	73
Spinal cord.....	1	1		0	1	1	0	3	7
Chest.....	9	5		18	24	12	12	7	87
Abdomen.....	8	1		6	12	9	5	2	43
Extremities.....	94	27		73	182	70	73	49	568
Skin (burns).....	2	1		1	0	0	0	0	4
Severe Shock									
Brain.....	28	8		29	30	20	15	10	140
Maxillofacial.....	5	1		3	9	1	8	2	29
Spinal cord.....	0	2		9	8	2	3	1	25
Chest.....	22	10		23	40	27	25	11	158
Thoracoabdominal.....	9	6		16	7	8	14	3	63
Abdomen.....	10	3		25	20	24	36	16	134
Extremities.....	23	13		83	264	76	64	62	585
with gas gangrene.....	11	1		0	18	5	1	1	37
Skin (burns).....	9	1		1	3	0	0	1	15
Total admissions.....	384	120		333	634	276	279	187	2213

* The hospital was inactive during the month of September.

Although there were 2,213 admissions to the shock ward during the eight-month period covered in this paper, the statistical data have been restricted to the first 2,000 charts.

of both blood pressure and pulse to atropine sulfate Gms. 0.0013 intravenously.

GENERAL METHODS OF SHOCK TREATMENT

The general treatment of shock is too well established to warrant routine comment. However, the necessity for a complete physical examination and for the redressing of all wounds must be stressed. Without these precautions, a sucking chest wound, crepitation and odor in an extremity wound, or evisceration in an abdominal wound may be overlooked. To be condemned is the occasional use of alcoholic beverages in the battalion aid station, as the vasodilation secondary to alcohol is distinctly prejudicial to shock.

FLUID REPLACEMENT

The most important factor in the treatment of shock is fluid replacement that is both quantitatively and qualitatively cor-

rect. In an evacuation hospital this must be determined to a great extent by clinical judgment, because the amount of laboratory work that can be done is limited. A discussion of the factors which determine the type and amount of fluid replacement is justified by the paramount importance of this phase of shock therapy.

Quantity. The amount of fluid required is determined by a combination of several factors: (1) General appearance and condition of the patient on admission, (2) estimated blood loss prior to admission; (3) amount of dehydration; and (4) estimation of expected blood loss in the operating room.²

In the presence of so many variables, there can be no inflexible rule for the volume of fluid required. We have found that it is more common to under-hydrate than to over-hydrate. The observations recorded on Table II indicate the relative

TABLE II

THE EFFECT PRODUCED BY A LARGE AMOUNT OF BLOOD, PLASMA AND CRYSTALLOIDS ADMINISTERED TO ONE PATIENT OVER A PERIOD OF TWENTY-FOUR HOURS

A private, thirty-four years old, was wounded four hours before admission to this hospital. His dressing had been changed at a medical collecting company because of fresh bleeding.

Diagnosis: Compound fracture of the left femur, tibia and fibula with destruction of the left knee joint.

Time in Hours	Fluids	BP	Pulse	Venous Pressure MM H ₂ O	Hematocrit	Specific Gravity Plasma	Total Protein	Urine Output, Cc.
0100		104/80	116					
0100-0300	1,000 cc. saline 500 cc. whole blood							
0300		120/72	136					
0300-1100	1,000 cc. whole blood 2,000 cc. dextrose 5% in saline 1,000 cc. dextrose 5% in water 750 cc. plasma							
1100		90/60	160	100	28	1.018	3.7	
1100-1200	1,000 cc. saline							
1200		90/50	148	140	28	1.018	3.7	
1200-1245	1,000 cc. dextrose 5% in water							250
1245		90/50	150	170	26	1.018	3.7	
1245-1500	2,000 cc. dextrose 5% in water							1,000
1500		90/50	140	120	25	1.017	3.4	
1500-1600	600 cc. whole blood							
1600		100/40	150	110	28	1.018	3.7	
1600-1700	750 cc. plasma							200
1700		120/50	130	118	30	1.019	4.4	
1700	Sent to operating room							
1700-0100	700 cc. whole blood							350
0100		110/70	96	112	40	1.022	5.4	

	Total Intake, Cc.	Total Output, Cc.
Whole blood.	2,800	
Plasma....	1,500	
Saline.	2,000	
5% dextrose in saline	2,000	
5% dextrose in distilled water.....	4,000	
	12,300	1,800

The patient, a chronic alcoholic, belonged to blood group "A." Difficulty in obtaining compatible blood was encountered as cross-matching revealed his blood to be incompatible with stored group "O" blood. Improvement was maintained after operation, and the patient recovered.

safety of administering large amounts of fluid to a patient in severe shock, and show the effects produced by the fluids.

That the amount of blood required may be large is illustrated by one patient who suffered from an abdominal wound with a laceration of the inferior vena cava. He was given 7,500 cc. of whole blood pre-operatively and during the operation. After ligation of the inferior vena cava the

hemorrhage ceased and the patient made a good recovery. A full report of this case has been submitted for publication by Major Robert W. Fraser.

The blood pressure and pulse are valuable guides in determining the actual amount of fluid required only if they are constantly correlated with the patient's clinical condition. They cannot be relied upon exclusively for the following reasons:

(1) Bradycardia and hypertension have both been observed in the presence of clinical shock.

(2) In many instances a slight tachycardia and a normal blood pressure on admission do not indicate the fact that the patient is barely compensating for an extensive loss of blood (Case 1).

(3) A patient, whose extremities are cold and whose blood pressure and pulse are imperceptible on admission, may be restored to normal blood pressure and pulse with as little as 1,000 cc. of blood in one hour. It is obvious that a loss of more than one liter of fluid was required to produce hematogenic shock of such degree, and therefore unwise to assume that the fluid demands have been met as soon as the blood pressure and pulse return to normal.

(4) There is a small group of patients whose shock is apparently due to the absorption of toxins and not to fluid loss alone. In this group, it is illogical to expect that replacement of fluid will result in a return of the blood pressure to normal; therefore, it would be fallacious to use the blood pressure as a guide to the amount of fluid required.

(5) There are occasional patients who, despite a certain blood loss, would not be given a blood transfusion except that the possibility of extensive hemorrhage during operation makes it advantageous to start the operation with a full haemic component (Case 11).

CASE REPORTS

CASE 1. A patient was admitted with a penetrating wound of the abdomen, a pulse of 120 and a blood pressure of 105/70. Despite the relatively normal blood pressure, the general appearance of the patient suggested acute blood loss, and a blood transfusion was started in each arm. One hour later his pulse was 112 and blood pressure 110/80. He was taken to the operating room, where, after being moved from a litter to the operating room table, he showed evidence of profound circulatory collapse. His pulse was 150 and his blood pressure was 80/50. He was perspiring and his respirations were rapid and labored. More blood was

given rapidly and the operation started. It revealed a massive retroperitoneal hemorrhage which had been caused by a laceration of the external iliac vein. Despite the relatively normal blood pressure and pulse on admission, it is clear that the blood loss had been large but that active bleeding had ceased. When he was moved to the operating room, after the blood volume had been only partially restored with 1,000 cc. of blood in one hour, a clot was dislodged and bleeding recurred. A small additional loss of blood now quickly produced circulatory collapse. Blood pressure and pulse had been poor indications of the actual blood volume and the necessity for treatment.

CASE 11. A patient was admitted with a tremendous foreign body in the chest cavity. His pulse was 84 and blood pressure was 140/100, and there was no evidence of massive hemothorax or air hunger. An x-ray revealed that the foreign body apparently extended into the hilus of the lung. Because hemorrhage following its removal seemed likely, the patient's blood was cross-matched and a transfusion of whole blood was started immediately preceding the operation. At operation, very brisk bleeding followed the removal of the shell fragment which had lacerated the main bronchial artery; the patient might have died had the operation been undertaken prior to the restoration of blood previously lost.

Type of Fluid. With the exception of burn cases, most surgical shock seen in war casualties is due to the rapid loss of whole blood. The almost invariable response to transfusions of whole blood indicates that there are few patients in whom this is not true. Hemoconcentration, although demonstrated in occasional instances, was seldom significant, and generalized fluid loss through permeable capillary endothelium did not seem to be important.³ Therefore, the one essential therapeutic fluid is blood, and for it there is no real substitute.

As a supplement to the blood used, the choice lay essentially between plasma and one of the crystalloids, for albumin was not available.⁴ With the exception of those instances in which there is a distinct indication for the use of plasma, one of the crystalloids is preferable for the following

reasons: (1) Serious reactions occasionally follow the use of plasma. Although we have had no fatalities from plasma, urticaria is not infrequent and temperatures to 108°F. measured per rectum have been produced. Serious reactions from the use of the crystalloids have not been observed. (2) Economy and ease of production of the crystalloid solutions; (3) ease of administration; and (4) the restorative effect of crystalloid infusions is scarcely distinguishable from results obtained with plasma, except in burns, and in the most severe types of shock.

In the treatment of mild or compensated shock we have used the crystalloids almost exclusively. As a supplement to whole blood, their importance in replacing the depleted extracellular fluid volume is unequivocal.

In actual practice we have completely ignored the original four plasma to one blood ratio rule as this introduces the cellular elements in too dilute a form. For the treatment of hematogenic shock, we have used plasma as a sustaining fluid while obtaining cross-matched blood, and occasionally as a hypertonic solution in the treatment of pulmonary edema or in the correction of hemoconcentration after the depleted extracellular fluid has been replaced by the crystalloids.

SURGICAL TREATMENT OF PATIENTS IN SHOCK

There is a significant number of patients who must receive surgical treatment while still in shock. These patients may be divided into four groups: (1) Those who without obvious reason fail to improve after adequate fluid replacement, (2) those who exhibit signs of respiratory obstruction; (3) those with uncontrolled hemorrhage; and (4) those with upset respiratory mechanics.

It soon became apparent that the optimum benefit from adequate fluid replacement could be observed within a maximum of five hours. If at the end of that time the patient had not recovered from shock,

it was evident that whatever had produced the shock was perpetuating it, and that fluid replacement was not the complete answer to the problem. This was particularly true in the case of injuries to the extremities where gas gangrene, infection, muscle necrosis, and possibly subclinical infection of clostridial origin were constant threats and where waiting beyond a maximum of five hours might mean fatality.

With respect to respiratory upset, if the normal mechanism cannot be restored by conservative measures, and if fluid replacement has failed to increase the cardiac output in the presence of mechanically disturbed respiratory physiology, then corrective surgery offers the only solution and must not be postponed. Table III summarizes the results obtained on the patients subjected to surgery before shock had been controlled.

CAUSES OF FAILURE TO RESPOND TO SHOCK TREATMENT

The vast majority of patients respond dramatically to the transfusion of whole blood. Most frequently pulse and blood pressure, which were imperceptible on admission, were within normal limits after the first hour of treatment, and long before the fluid replacement was complete. If this expected response is not observed, the cause of the protraction of the shock must be sought immediately. It is largely the time factor in shock which permits decompensation to become irreversible. We have found that the most frequent causes of failure are: (1) Positive intrapleural pressure due to pneumothorax or hemothorax, or both, and usually associated with mediastinal shift; (2) acute gastric dilation; (3) unsplinted or inadequately splinted fractures, particularly those involving the knee joint; (4) exsanguination; (5) gas gangrene toxemia; and (6) probable toxic absorption from certain extremity wounds.^{5,6}

Instances of toxic absorption most frequently follow injuries due to mine explosions, and are characterized by extensive muscle destruction and necrosis. Although

TABLE III

ANALYSIS OF THE NINETY PATIENTS WHO WERE SENT TO THE OPERATING ROOM IN SHOCK

Region	No. of Patients	Reason Sent to the Operating Room in Shock	No.	Survived	Died
Brain.....	9	(1) Extensive intracranial destruction with no response to prolonged treatment	7	2	5
		(2) Subdural hematoma	2	2	0
Spinal cord.....	1	(1) Hemorrhage from the external jugular vein	1	1	0
Chest.....	8	(1) Mechanical respiratory difficulty	6	3	3
		(2) Increasing hematoma of the neck	1	1	0
		(3) Hemorrhage	1	0	1
Thoracoabdominal.....	9	(1) Mechanical respiratory difficulty	4	0	4
		(2) Uncontrolled hemorrhage	5	4	1
Abdomen.....	18	(1) Uncontrolled hemorrhage	9	4	5
		(2) Intestinal perforation(s) with peritonitis	9	3	6
Extremities.....	45	(1) Suspected that shock was being protracted by the absorption of an unidentified toxin or factor	27	23	4
		(2) Uncontrolled hemorrhage	11	8	3
		(3) Gas gangrene toxemia	7	4	3
Totals.....	90		90	55	35

the toxin, if it exists, is unidentified, the behavior of these patients closely parallels that of the patient who is overwhelmed by the toxins of the gas producing organisms.

TRANSFUSION REACTIONS

Although an absolute necessity in shock therapy, the use of preserved group "O" blood introduces a cause of anxiety, namely that of transfusion reaction. In 6,003 whole blood transfusions given during the eight-month period covered in this paper, there were 101 severe reactions. There were four fatalities that we directly attributed to a transfusion reaction, and in three additional instances, we believed a transfusion reaction to be a contributing factor to the mortality. In twelve other instances, autopsy revealed evidence of gross kidney disorders that could not be directly attributed to trauma; we believe that hemoglobinuria in the presence of renal ischemia consequent to prolonged shock is a determining factor in the production of anuria, and have therefore included these patients as fatalities due to transfusion reaction.

Because of the danger associated with the use of group "O" blood, we have found the following precautions to be essential:

(1) If the patient exhibits a chill at any time during a transfusion, plasma or saline should be substituted for the blood until a cross-match can be performed. There are at present no criteria which will immediately differentiate a pyrogenic reaction from one due to minor incompatibility. However, in occasional instances when it is believed that a forty-five-minute delay in whole blood replacement would be fatal, it becomes necessary to disregard the possibility of a reaction.

(2) If large amounts of blood are to be required (over 2,000 cc.) a certain amount of hemolysis is to be anticipated, and it is therefore advisable to perform a cross-match. In such cases, particularly if the patient belongs to any group but "O," we have started a blood transfusion immediately and at the same time cross-matched the patient's blood. The patient then receives only cross-matched blood after the first 1,000 cc. Despite this precaution some hemolysis of the recipient's cells due to incompatibility in the minor match is to be expected. The actual amount of hemolysis produced varies directly with the rapidity with which the blood is introduced.

(3) If more blood is to be given to the same patient after a four to five-day interval, it is better to give cross-matched blood only. Also one now encounters the

TABLE IV
A SUMMARY OF THE DATA PERTINENT TO THE
TRANSFUSION REACTIONS

Admissions to Shock Ward	Total Number of Blood Transfusions Given
384	July..... 701
120	August..... 290
333	October..... 1080
634	November..... 1718
276	December..... 900
279	January..... 776
187	February..... 538
2213	6003

Total number of cross-matches performed—427

Total number of patients whose blood was incompatible with preserved blood—55

Total number of live donors used:

A—80 AB—6

B—31 O—16

	Number	Per Cent of Total Transfusions	Hemoglobinuria
Severe reactions.....	101	1.6	21
Reactions apparently producing fatality.....	4	0.06	3
Reactions contributing to fatality.....	3	0.05	1
Renal disorders which may have been due to undetected transfusion reaction.....	12	0.19	2

Severe reactions according to groups (recorded in 83 per cent of the 101 reactions)

A—42 AB—1

B—12 O—29

Total number of patients operated upon—10,700

Total mortality—326 or 3 per cent

Of the 326 deaths:

Reactions to transfusion apparently producing fatality—4 or 1.2 per cent

Reactions contributing to fatality—3 or 0.92 per cent

possibility of having produced anti-Rh antibodies (specific Rh positive agglutinins) in the serum of an Rh negative patient.⁷ As there is no method available at the evacuation hospital level for detecting this, we have made the indications for transfusion after a four to five-day interval very rigid.

(4) Preserved group "O" blood should never be given as a tonic, and must be restricted to use as an emergency measure only.

Hemoglobinuric nephrosis is a constant threat, particularly when it is necessary to administer more than 2,000 cc. of preserved group "O" blood. Postoperative urinalyses have revealed twenty-seven examples of hemoglobinuria; there were undoubtedly others which passed undetected. In the prevention and treatment of the associated oliguria, we have been most impressed with the necessity for maintaining an adequate fluid balance. Routine alkalization has seemed less important for the following reasons:

(1) A total of 6,003 blood transfusions have been given. Autopsies on the 251 fatal cases during this period of time have demonstrated only one instance of gross hematin precipitation. It is to be noted that although all patients did not receive alkaline therapy, the particular patient in whom gross hematin precipitation could be demonstrated had been alkalized.

(2) If the primary lesion is assumed to be necrosis of the distal tubular cells and the precipitation of acid hematin a secondary and possibly unessential part of the syndrome, the alkalization might be expected to be ineffective. Furthermore, if unexcreted, the large doses administered might produce sufficient alkalosis to decrease glomerular filtration.

The figures for the total number of transfusions given, the total number of patients treated on the shock ward and the total number of cross-matches performed have been included on Table IV. In the absence of this information, the total number of reactions is without significance.

Mortality Statistics. Table V has been compiled from autopsy reports, and although death was often due to a combination of factors, only the principal cause has been assigned in each case.

SUMMARY AND CONCLUSIONS

1. An evaluation of the treatment of 2,000 consecutive patients on the shock ward of an evacuation hospital is presented.

2. Hypertension, being an indication of vasoconstriction, is considered compatible

TABLE V

CAUSES OF DEATH IN PATIENTS TREATED FOR SHOCK

Brain.....	83
Cerebral destruction.....	69
Subdural hematoma.....	3
Meningitis.....	3
Pneumonia.....	2
Intraeranian hemorrhage.....	1
Blast concussion.....	1
Cerebritis.....	1
Renal failure.....	1
Aspiration.....	1
Laceration longitudinal sinus.....	1
Maxillofacial.....	4
Shock.....	2
Anesthesia.....	1
Renal failure.....	1
Spinal cord.....	11
Respiratory paralysis.....	9
Peritonitis.....	1
Pneumonia.....	1
Chest.....	28
Intrapulmonary hemorrhage.....	9
Blast.....	5
Shock; hemorrhage.....	7
Pneumonia.....	3
Diaphragmatic hernia.....	1
Respiratory embarrassment.....	1
Renal failure.....	1
Blast lung and brain.....	1
Thoracoabdominal.....	29
Shock; hemorrhage.....	13
Peritonitis.....	6
Pneumonia.....	5
Tension pneumothorax.....	1
Intrapulmonary hemorrhage.....	1
Transfusion reaction.....	1
Renal failure.....	1
Diaphragmatic hernia.....	1
Abdomen.....	47
Peritonitis.....	18
Hemorrhage.....	11
Pneumonia.....	11
Intestinal obstruction.....	1
Renal failure.....	1
Retroperitoneal infection.....	1
Duodenal fistula.....	1
Extremity with gas gangrene.....	48
Gas gangrene toxemia.....	11
Shock; hemorrhage.....	9
Pneumonia.....	6
Shock.....	6
Shock; muscle necrosis.....	5
Anesthesia.....	3
Transfusion reaction.....	3
Gas gangrene antitoxin.....	2
Pulmonary embolus.....	1
Renal failure.....	1
Blood dyscrasia.....	1
Skin (burns).....	1
Laryngeal edema.....	1

All patients who were treated on the shock ward and subsequently died, were included in the mortality statistics regardless of the cause of death and the post-operative day on which it occurred.

with the diagnosis of shock; it should not be regarded as proof that shock does not exist, nor as a contraindication to shock therapy.

3. Bradycardia in the presence of shock occurred more frequently than was anticipated. The dramatic response to intravenous atropine sulfate in two cases suggests that it may be due to vagal stimulation.

4. The qualitative and quantitative requirements for fluid replacement are considered, and the lack of close correlation between blood pressure, pulse and actual fluid requirement is pointed out. The primary importance of blood is stressed, and the indications for plasma and the crystalloids are discussed.

5. Indications for the surgical treatment of patients still in shock are given with results obtained.

6. The most common causes of failure to respond to adequate fluid replacement are outlined.

7. The problem of transfusion reactions and the clinical status of alkaline therapy are discussed.

8. Mortality statistics for all shock patients are included.

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A REVIEW OF THE BLOOD DONOR SERVICE OF THE AMERICAN RED CROSS

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DONATIONS of 13,326,242 pints of blood were made by approximately 6,660,000 voluntary donors from February 4, 1941, through August, 1945. Donors averaged two donations, approximately 1,500,000 gave three pints each, 150,000 gave a gallon and 3,000 gave two gallons or more. These volunteers provided the essential material, their blood, which made this gigantic project possible and at least 100,000 additional volunteer workers contributed unstintingly of their time and enthusiasm in countless ways to make this work a success.

The American Red Cross Blood Donor Service was inaugurated at the request of the Army and Navy as a joint undertaking of the American Red Cross and the National Research Council. The blood was donated to these services and was always at their disposal.

The service was expanded rapidly and at its height, donor centers were in operation in thirty-five cities, aided by sixty-five mobile units.

The National Research Council assumed responsibility for endorsing all technical and scientific procedures and the Red Cross all other responsibilities.

A National Director and a National Technical Director were appointed early and under their direction the same techniques and methods were installed in all centers, giving an essential unification of the work everywhere. It is impossible to mention the many individuals who made major contributions to this many sided project. Only a few of the scientific studies have been published. The essential importance of work in recruiting donors, in the publicity field, in conducting the canteens, in many tiresome routine clerical and technical jobs cannot be properly real-

ized except by those who had the privilege, through helping, of seeing these and many other phases of the work. In contrast to the large number of volunteer workers there were only 280 paid lay workers, 975 nurses, thirty-one doctors and approximately ninety-six doctors assigned from the Army and Naval Medical Corps. From the beginning there were two main objectives: to procure the amount of blood requested by the Armed Services and at the same time to take every precaution to protect and care for the donors. Not infrequently it was a difficult problem to persuade donors that they should not make a blood donation. This was especially true with many women who needed longer than the usual time to regenerate blood after a previous donation.

Careful and detailed regulations were formulated to govern all phases of the service—but they can only be given here in brief and abstract form. These include system of registration, age limits, physical requirements, care of donors before, during and immediately after bleeding, technic of vein puncture and bleeding, refrigeration, care of the bottles of blood and their rapid transfer to processing plants, etc. A complete report has been prepared by the National Director and will be released soon.

Donors between twenty-one and sixty years of age were accepted and also between eighteen and twenty with written consent of parents. Donors were requested not to eat a fatty meal and if possible to refrain from food for three to four hours before coming to the center. Careful and systematic questions were asked about present health and feeling of well being; recent illnesses, especially respiratory infections; malaria within fifteen years,

jaundice within six months, shortness of breath, asthma and definite allergic conditions, epilepsy, etc. A normal mouth temperature was required, and systolic blood pressure between 100 and 200 mg. of mercury and diastolic not above 110.

It was especially important to use a simple, rapid and accurate method for hemoglobin determination. It soon became evident that it was necessary, especially for women donors, to safeguard them by requiring a sufficient level of hemoglobin, in particular before repeat donations. After careful investigation of the literature and extensive consultation the minimal acceptable level was fixed at 12.3 Gm. of hemoglobin per 100 cc. of blood. The method used was an adaptation of the copper sulfate specific gravity method of R. A. Phillips and collaborators.* A single solution of copper sulfate of a specific gravity of 1.052 was used. If a drop of blood sinks immediately when dropped into this solution its specific gravity is greater than 1.052 and this indicates a hemoglobin content of 12.3 Gm. or more per 100 cc. of blood and the donor is acceptable. If the drop of blood does not sink immediately, the hemoglobin content is insufficient to allow a donation of blood. This simplified method was carefully checked by several comprehensive methods. Hundreds of volunteer workers learned to use this method quickly and accurately.

Whenever any question arose of suitability of a donor or inadvisability of a donation, for safeguarding the donor, the problem was referred to the physician in charge. He or she interviewed the donor, asked more searching questions when necessary and repeated any examinations when this was indicated.

All donors were required to drink a glass of water or of lemonade immediately before being bled. Each donor, after the blood donation, was accompanied by a volunteer worker to the canteen where coffee, tea, milk, soft drinks, crackers and cookies were

provided. A nurse was in constant attendance to watch the donors during this rest period and to notice any tendency towards feeling ill or fainting. Rest on cots provided, in small rooms or cubicles, for the small percentage of donors who needed rest and observation or treatment. It was expected that some donors would faint and some fainted even before their donation or following the finger stick to obtain a drop of blood for hemoglobin determination. In a careful survey no serious effects or fatalities could be attributed directly to donation of blood. Fainting seemed to occur at times in waves; after one donor fainted others would unexpectedly do so. Also very occasionally bleeding would precipitate a spasm or even a general convulsion. These also, as far as is known, caused no serious after effects.¹

The donors reclined on tables of operating room table height. After cleansing and sterilizing the skin over the veins at the bend of the elbow a drop of $\frac{1}{2}$ per cent novocaine was injected intradermally over one vein. Vein puncture was therefore painless. Specially devised bleeding sets were used, each bottle containing 50 cc. of 4 per cent solution of trisodium citrate. The sets were sterilized by autoclaving each in a cloth bag. The blood entered the bottle by gravity, there being a protected air vent through the stopper of the bottle. The bottle was given a smooth, rotating movement at frequent intervals for mixing citrate solution and blood and preventing clots. After withdrawing the needle from the vein, a pilot test tube was filled with blood remaining in the rubber tube. This sample was used for serological and other tests.

The bottle of citrated blood was placed in a refrigerator immediately, and kept refrigerated in specially designed boxes during transmission to the processing plants, and there kept refrigerated during the entire process of separating the plasma from the cells. This separation was completed within seventy-two hours of the time the blood was obtained. The processing was carried out at about ten commercial

* BOYNTON, M. H. The use of the copper sulfate method of hemoglobin estimation for screening blood donors. *J. Lab. & Clin. Med.*, 31: 40, 1946.

laboratories throughout the country, and under contracts with the Army and Navy. Representatives of the Biologics Division of the National Institute of Health supervised and controlled this part of the work. The laboratories expanded their plants and increased and trained their personnel with astonishing rapidity. They also gave cooperation of a high order not only with the American Red Cross and the Services but also with one another, sharing information of methods, technics and general "know how." This is evidenced in a concrete manner by an extremely low percentage of loss from breakage, contamination, etc.

Serological tests for syphilis were performed on each sample. Only serologically negative plasmas were pooled. Pools were made of the plasma from twenty-five or more bottles, and immediately distributed into the final containers. At first 300 cc. of citrated plasma and after a short interval 500 cc. were placed in each bottle. Immediately afterwards, the plasma was shell frozen in each bottle, at about minus 70°C., and stored at about minus 20°C. As soon as bacteriological control tests of the liquid pools released them, the plasma was dried from the frozen state with the aid of a high vacuum and careful temperature control to prevent thawing during the drying process. Small pilot samples of frozen plasma were also dried and cultured before the final dried product was released. The dried plasma was porous, uniform in appearance and cream colored or light yellow in color. It rapidly dissolved, i.e., in one to five minutes, when pyrogen free distilled water containing a small fraction of a percent of citric acid was added.

Each bottle of plasma was put in a tin can and hermetically sealed. Another bottle containing the volume of distilled water necessary to restore the dried plasma to its original volume was also packed in a similar tin can. These two, with directions for rejuvenation and use, with needles for mixing and a sterile, expendable intravenous infusion set (including filter) were packed in a strong paste board carton. Groups of eight or ten of these were then

packed in larger cartons and delivered to the Army or Navy. The Services had on hand not only their necessary quotas but a reserve for any emergency requirements. As is well known an ample supply of plasma was distributed to our forces all over the globe, to all ships, airports, hospitals and even to front lines and invasion beaches.

While this work was going on E. J. Cohn² and his group perfected and developed remarkable methods for fractionating plasma into a number of important fractions including liquid, serum albumin for the intravenous treatment of shock, Gamma globulin, useful in prophylaxis of measles, infectious hepatitis and perhaps other diseases; thromboplastin for controlling hemorrhage, either alone or when combined with fibrin foam, fibrin films for covering brain areas at operation and minimizing or preventing adhesions; and iso-agglutinins of blood groups A and B for blood grouping tests. This does not include the entire list and the publications of this group can be consulted for complete reports and for details. For these important products a large amount of plasma was diverted to the pilot plant of the Harvard group of investigators and to a number of processing plants. The supply of plasma permitted this without interfering with the dried plasma supply to the Services.

For a while no large scale use could be made of the cell residue after the plasma was withdrawn. There had been small reports of use of resuspended cells for transfusion where the patients need was for cells, and oxygen carrying power and not for whole blood, as in chronic anemias, leukemias, etc. In Detroit, W. B. Cooksey³ made the first large use of resuspended cells for these purposes. The packed cells were resuspended in physiological saline solution and had to be transfused not longer than five days after they were drawn. They were used in local service and civilian hospitals in large amounts with excellent results. Only Group O cells were distributed to simplify their use and to avoid mistakes of using incompatible cells. Later a similar project was instituted in

New York City. After awhile it was found that a solution of 10 per cent corn syrup in distilled water could be used for resuspending the cells and would increase the safe period of storage before transfusion to fourteen days.⁴ This gave greater leeway to use in hospitals and 9,000 transfusions were performed in about twenty service and civilian hospitals with cells suspended in 10 per cent corn syrup. They were used with beneficial results and without any deleterious effects.

Another use for red cell residues was found by M. M. Strumia⁵ and his group. They prepared a purified globin solution which they found useful in treating shock, acting in somewhat the same manner as a 25 per cent solution of serum albumin.

At the termination of the war stocks of some of the products described remained on hand. Some of these are being distributed for civilian use, so that many civilians who donated blood are directly benefiting by their wartime generosity. Considerable amounts of the gamma globulin fraction has been distributed on a nation wide basis through health departments for ameliorating or preventing measles in children who have been directly exposed to infection with this disease. Similarly, large amounts of dried plasma have been distributed to hospitals for civilian use. Some of the other products have also been available.

It was recognized early that adequate treatment of hemorrhage and shock due to hemorrhage, required immediate transfusion of whole blood. Blood banks had been set up in the European theatre of operations, but while they functioned well, their facilities were inadequate.

Accordingly, in August, 1944, at the request of the Surgeon Generals of the Army and Navy, a project for the procurement of whole blood in the continental United States and its shipment to the various combat zones was jointly undertaken by the Army and Navy in cooperation with the Red Cross Blood Donor Service. Plans had been in readiness for this request and had been formulated by the Department of Surgical Physiology of the

Army Medical School⁶ and the Plasma Laboratory of the Naval Medical School. The technics used were based on the liquid plasma program of the Army and Navy.⁷

The procurement, collection, preservation and shipment of whole blood presented problems of a different technical nature than those of the dried plasma program. Since the whole blood was destined for use in combat zones, it was anticipated that no compatibility tests could be made at the time of transfusion. Only group O blood, the so-called "universal donor" blood, could be of value, as properly prepared group O requires no cross-matching before administration and can be given to recipients of any blood group without danger.

Procurement. Whole blood laboratories were set up in already existing Red Cross Blood Donor Centers in twelve cities. Previously, it had been unnecessary to perform blood groupings on the donors for the plasma program. To avoid doing complete blood groupings, all donors were screened for group O only. At the time the hemoglobin content was being determined, a drop of the donor's blood was placed in a small vial of normal saline. A few drops of this cell suspension were then placed in another vial containing dried group O serum. This serum was specially prepared and had both a high anti A and anti B agglutinin titer and a high avidity index. After ten to fifteen minutes, while other routine tests were taken of the donor, the vial was examined. The absence of agglutination denoted on O donor, while its presence signified that the donor was not group O. The O donors were bled by a special technic while those who were not group O were handled in the usual manner. In this way, bleedings for whole blood and for plasma took place in the same bleeding room and the selection was made without any disturbance of routine or loss of time.

Collection. The original container into which the donor was bled would also be the container at the time of the actual transfusion. Accordingly, the closed system vacuum, technic was adopted because it afforded the optimum protection against

bacterial contamination. In addition, with this system and with special attention to the preparation and cleaning of tubing and needles, pyrogen contamination could be eliminated. The nursing personnel who performed the actual phlebotomies were specially trained in these technics. It is worthy of note that due to the ability and conscientiousness of these nurses, reports from the field revealed an unprecedented low rate of reactions.

Preservation. To be of practical value, the solution used to preserve whole blood destined for overseas use must of necessity adequately preserve the red cells for a minimum of fourteen days. At the time the whole blood program began, Alsever's solution was the best available and was used during the first few months. This was a very adequate preserving solution, but because of its bulk—500 cc. of fluid to 500 cc. of blood—was somewhat unsatisfactory. On the basis of experimental work done by the Sub-committee on Blood Substitutes of the National Research Council, the Loutit-Mollison ACD solution was later substituted for the Alsever's solution. ACD solution is a mixture of sodium citrate, citric acid and dextrose. It has the advantage of requiring only 120 cc. of fluid to 480 cc. of blood. This solution proved quite satisfactory and maintained the red cells in a good state of preservation for a minimum of twenty-one days, based on cell survival studies, rate of hemolysis and potassium content. An expiration date of twenty-one days after the date of collection was placed on the label of each bottle shipped overseas.

Refrigeration. Regardless of the preserving solution used, the degree of preservation of red cells is in direct proportion to the constant maintenance of refrigeration of the blood at temperatures ranging from 4° to 6°C. Temperatures lower or higher than these cause excessive hemolysis. Considerable efforts were made to maintain this temperature range. All bleeding bottles were pre-cooled to 4°C. before use. As soon as possible after collection the blood was placed in refrigerators constantly

maintained by a thermostat at the proper temperature. Before facilities were available, the blood was shipped overseas in insulated containers and as soon as it reached its destination was placed in a refrigerator. Shortly after the start of the program, an expendable refrigerator using wet ice was developed which would maintain a temperature range for forty-eight hours of 5°C. to 10°C. while en route. Facilities were available for re-icing while in transit. While these temperature ranges were not ideal, nevertheless, the expendable refrigerator was a very practical factor in preserving the blood during shipment. This was of considerable importance since the blood was transported distances ranging from 3,000 to 8,000 miles from the collection point to the site of transfusion.

Testing. Each bottle of blood was immediately sent to the laboratory after collection, together with a pilot tube of 8 to 10 cc. of blood which were drained from the tubing of the bleeding set. The bottle of blood was placed in the refrigerator while the pilot tube of blood was used for the various tests. These included a proof typing for group O, a Kahn test, Rh testing and an agglutinin titration. Since as many as 1,500 pints of blood were processed in one laboratory daily, these tests were set up on a mass production basis. However, accuracy was not sacrificed for speed, as a check system proved the reliability of all tests.

(a) *Proof Blood Grouping.* The most important single test performed was that of the proof grouping for group O. The O bloods had been tentatively identified on the basis of the screening test. Before a bottle of blood was certified as O and shipped as such, it was proved to be so, since it was essential that only O blood be used, as blood other than O could cause a serious or fatal transfusion reaction if administered to an incompatible recipient. The test for proof grouping of O blood is based on the fact that the serum of group O blood contains both anti A and anti B agglutinins. If either or both of these are

not present in a serum, the blood cannot be group O. Hence, before a blood can be shipped as O, the presence in its serum of both anti A and anti B agglutinins must be determined. Anti A agglutinins are detected by testing the serum with known A cells, anti B agglutinins by testing with known B cells. If agglutination does not occur in both instances, the blood is not group O. Such non O blood was not sent overseas but was used in local military hospitals. The success of the screening test was well demonstrated by the fact that in over 380,000 such tests the error in grouping was 0.5 per cent.

(b) *Kahn Test.* The standard three-tube Kahn test was performed routinely on all blood specimens. All doubtful or positive Kahns were checked with the Wassermann test. Bloods with positive Kahns or with doubtful Kahns confirmed by the Wassermann test were discarded. The combined incidence of doubtful and positive Kahns amounted to 0.4 per cent.

(c) *Rh Testing.* It was known that Rh negative recipients may develop Rh antibodies if transfused with Rh positive blood, particularly if multiple transfusions were given. Since multiple transfusions for the treatment of severe casualties were the rule rather than the exception, it was necessary to provide Rh negative recipients with Rh negative blood. Accordingly Rh testing was performed by the technic as described elsewhere⁸ and a quantity of Rh negative blood specifically labelled as such was shipped each day.

(d) *Agglutinin Titration.* As already stated, properly prepared group O blood can be given to recipients of any blood group without reaction. This means group O blood with a low agglutinin titer. Group O blood contains both anti A and anti B agglutinins. It is theoretically possible that such agglutinins can cause destruction of A, B and AB cells. Practically, it was believed that this occurs only when the titer of these agglutinins is over 1-600 by the tube centrifuge technic. Accordingly titrations for anti A and anti B agglutinins were performed on every serum by a

method detailed previously. A titer of 1-600 was chosen as the arbitrary dividing line. Those bloods with titers under 1-600 were shipped as "universal donor" blood and those with titers over 1-600 were specifically marked: "This blood contains a high titer of anti A and/or anti B agglutinins and should be given only to an O recipient." Recent work, however, indicates that a titer of 1-200 by the tube centrifuge technic would be a safer point at which to separate high and low agglutinin content.⁹

Witebsky and his associates¹⁰ have for some time advocated the routine addition of A and B specific substances to group O blood in order to neutralize the anti A and anti B agglutinins. Recent experimental work has corroborated their findings to the extent that the use of A and B specific substances to prepare O blood as universal donor blood is now recommended for military purposes.¹¹ However, their use to condition O blood for transfusions to women of the childbearing age is potentially harmful.

Checking and Packing of Blood. In addition to the various laboratory tests performed, a comprehensive system was developed of checking the numbers on the blood bottle and pilot tube to insure that no clerical errors were made. Each blood was kept in the refrigerator at 4°C. until ready for final shipment. Before being packed in the expendable refrigerators, the blood was carefully checked for short collections (less than 350 cc.), excessive hemolysis or fat, and the presence of clots. All bloods with any of the foregoing were discarded as well as those with a positive Kahn. In addition, bloods which were not group O were removed for use in local military hospitals. All Rh negative and high agglutinin titer bloods were checked to insure their proper labelling.

Just prior to shipment the bloods were packed in the previously iced expendable refrigerators. Twenty-four bottles, each containing a pint of whole blood, were packed in each box. In addition, twenty-four sterile pyrogen free intravenous sets

with filters, packed in a vacuum sealed can were shipped in the cover of each box. The set was completely adequate for performing a transfusion. These sets were expendable and were intended for use only once. The use of these sets contributed in great part to the low reaction rate that resulted from these transfusions.

Shipping. All whole blood was shipped by air. Shipments to the European theatre were handled by the Army Air Transport Command and those for the Pacific by the Naval Air Transport Service. The highest priority was given these shipments. A maximum of twenty-four hours elapsed between the time of collection and the take off by plane. Both air Services gave the fullest cooperation. Facilities for re-icing and the checking and storage of blood if delayed, were available throughout the route. Both theatres of operations had worked out an extensive distributing system so that blood was often being transfused at the front lines forty-eight hours after its collection.

Results. It is obviously impossible to determine scientifically and accurately the reaction rate of transfusions administered under combat conditions. However, on the basis of official reports, eye witness accounts and the related experiences of hundreds of Army and Navy physicians, it may be conservatively stated that the results of the use of whole blood shipped from the United States were most beneficial and that the reaction rate at least approximated those prevailing in the best civilian hospitals in this country.

Some 380,000 pints of whole blood were procured, processed and shipped in the manner described and with the excellent results as noted. Such a system with minor modifications can easily be adapted to large scale operations of civilian blood banks. A few such banks are already successfully operating. Plans are now in the developmental stage for the opening of large community blood banks to supplement the present inadequate facilities for supplying whole blood to civilian hospitals.

It was realized during the wartime devel-

opment of the blood donor service, that it offered a large scale opportunity for various observations and investigations and this opportunity might never recur. Advantage of this was taken therefore by many individuals and groups to pursue studies of various types. Reports of some of these have been published and undoubtedly others will be published in the near future. The entire project was a demonstration of collaboration and cooperation of huge numbers of people, from all walks of life and of a variety of skills and professions, to aid the war effort, to save the lives of our servicemen and to advance the art and science of medicine.

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THE USE OF BLOOD AND PLASMA IN THE TREATMENT OF BATTLE CASUALTIES

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AN accurate assessment of all therapeutic advances introduced into military surgery during the past few years is not as yet possible. It is certain, however, that one of the principal factors which contributed to a lessening of the mortality of battle casualties in the recent war was the availability of whole blood and plasma. Transfusions were frequently solely responsible for the successful evacuation of wounded soldiers to medical installations where definitive care was available. Similarly, in vast numbers of cases, extensive surgical procedures were feasible only through the agency of transfusion therapy, which compensated for further blood losses incurred during operation and which was required for the provision of adequate supportive care postoperatively.

Long prior to the war it was generally recognized that one of the prime considerations in the prevention and treatment of traumatic shock is the restoration of the blood volume. Accordingly, as a preliminary step in equipping the armed forces to combat shock, the Medical Corps of the U. S. Army and Navy was supplied with large quantities of dried pooled human plasma derived from blood donated by civilian volunteers. Plasma proved to be an adequate blood substitute for the correction of oligemia. Moreover, its stability over a wide temperature range obviated difficult storage and distribution problems; it could be packaged conveniently and administered with relative safety to recipients, irrespective of their blood groups, thereby eliminating the need for time-consuming compatibility tests. These were

highly estimable qualities, particularly from a military point of view, and it was anticipated that, in most cases, the transfusion requirements of the armed forces could be fulfilled amply by the sole use of plasma. The necessity for providing whole blood on a large scale was not seriously considered until it became evident, through practical combat experience, that the treatment of casualties who had sustained severe hemorrhages must include, not only the correction of a depleted blood volume, but also the maintenance of an adequate blood oxygen capacity. In order to meet this requirement, approximately eighteen months before the end of the war, adequate equipment became available for the venesection of local donors and for blood transfusion; most important, blood banks, organized in the various theaters of operation as well as in the United States, proceeded to effect an extensive and continuous distribution of stored whole blood to medical installations operating in combat areas.

THE RÔLE OF PLASMA IN WAR SURGERY

As the indications for the use of whole blood became increasingly clear, and with adequate facilities available for obtaining whole blood, the use of plasma began to assume a relatively subsidiary rôle in transfusion therapy. It nevertheless continued to be the mainstay of emergency shock treatment. In contrast to whole blood, plasma could always be supplied in adequate quantities, and in a satisfactory state of preservation, to the most advanced echelons of the Medical Corps. Through its

use an increase in blood volume could be effected with a minimum of delay, danger and technical difficulty, and for these reasons it proved to be of incalculable value in the prevention and correction of circulatory failure in recently wounded combat casualties, prior to their evacuation and the inception of their definitive treatment. Excepting in cases with serious wound hemorrhage and operative blood loss, the replacement therapy with plasma alone adequately sufficed; furthermore, in the resuscitation of patients following severe hemorrhage, it served to augment the volume of transfused protein fluid, thereby conserving the relatively limited supplies of whole blood. Plasma was also widely used for nutritional purposes, inasmuch as it was the only source of utilizable protein available which was suitable for intravenous injection. Finally, wisely or unwisely, plasma transfusions were employed as the chief form of replacement therapy in the treatment of burns.

The prime defect of plasma as a transfusion medium is, of course, its inability to transport oxygen, which limited its usefulness to an important extent. Circulatory collapse following severe hemorrhage could be averted by the use of plasma, but at the cost of producing, by erythrodilution, an anemia which could be extremely severe, depending on the total residual red cell volume and the amount of plasma injected. The complication of anemia proved to be a serious consideration from several points of view. It greatly jeopardized the prognosis of casualties who required extensive surgical procedures which involved general anesthesia and were attended by further blood loss. Its presence was especially deleterious in patients with chest wounds who suffered from impaired pulmonary ventilation and resultant anoxemia. The correction of this anemia, moreover, was a difficult therapeutic problem; for the preparation of concentrated red cell mixtures for transfusion was not feasible, and the more nearly complete a restoration of blood volume had been

accomplished through the use of plasma, the more nearly impossible became the task of increasing the red cell concentration by whole blood transfusions. A serious and common dilemma was presented by patients who, in addition to perforating chest wounds with intrapulmonary hemorrhage, had sustained a massive blood loss and whose blood volumes had been substantially restored by plasma infusion. This type of patient, severely anemic, but with a relatively normal blood volume, anoxemic as a result of pulmonary damage, and possibly requiring early surgery with general anesthesia, posed an extremely grave operative risk. Although demanding an optimal red cell concentration in view of the anoxemia, and with general anesthesia and further blood loss in prospect, blood transfusion at this stage was a precarious procedure, prone to enhance the pulmonary hemorrhage and to precipitate pulmonary edema.

The unrestricted use of plasma, unsupplemented by whole blood, thus proved to be a dangerous practice in the preliminary management of wound shock. As a result of practical experience, the policy eventually adopted was to use the minimum amount of this material that was required to maintain a level of arterial pressure consistent with safety, and to institute whole blood therapy as promptly as possible. For the prevention of "irreversible shock" the essence of treatment was not only the early correction of oligemia and hypotension, but the avoidance and treatment of severe anemia.

TRANSFUSION REQUIREMENTS IN THE TREATMENT OF WAR WOUNDS

The magnitude of the blood loss incurred as a result of various types of battle injuries was substantially greater than had been generally envisioned. This fact early became evident through deduction from the severity of anemia which commonly followed restoration of the blood volume to normal, either through spontaneous hemodilution or as a result of plasma

transfusion. Actual measurement of the blood volume in traumatic cases, carried out by several observers^{1,2,3} indicated that a reduction of as much as one-half of the normal blood volume, or 2,000 to 3,000 cc., was by no means a rarity, and that losses of between 1,000 and 2,000 cc. were not uncommon in seriously wounded soldiers. The severest hemorrhage was produced most consistently by extremity wounds, especially by traumatic amputations, and as a result of perforating wounds of the abdomen. It is noteworthy, moreover, that the average operative blood loss attending the surgical repair of perforating abdominal wounds was exceeded only by that accompanying extensive débridement of extremity wounds. The losses in these two types of procedures were frequently as great as 1,000 cc., and occasionally in excess of 3,000 cc.

Overall statistical data relative to the amounts of blood and plasma utilized in the treatment of battle casualties are not particularly illuminating, excepting as they pertain to the problems of procurement and supply. The magnitude of the volumes required for the early replacement therapy of non-transportable casualties due to abdominal, chest or severe extremity wounds are well illustrated, however, by the results of a survey conducted at the time of the Normandy campaign. In this it was found that the average volume of blood and plasma received by casualties admitted to Field Hospitals, estimated from the time of injury through the first postoperative day, was approximately 2,500 cc., of which blood and plasma comprised approximately equal amounts. Later in the course of the European war, when adequate supplies were ample to meet all requirements, relatively more whole blood was used in proportion to plasma.

The clinical criteria regarded as important in the regulation of transfusion therapy were by no means standardized, and there was little uniformity in their application throughout the Medical Corps. However, despite a considerable variation

in resuscitation procedures and transfusion policies, as carried out by individual surgeons and separate hospital units, there gradually emerged certain concepts pertaining to the therapeutic indications for the use of blood and plasma, the validity of which became generally accepted. It was recognized, for example, that certain types of wounds and operative procedures are almost invariably accompanied by a significant blood loss, which in large measure accounted for their "shocking" character.

Of all the clinical signs and symptoms indicative of blood volume deficiency, the most reliable, in practice, proved to be the level of the arterial blood pressure. It was well known, however, that this sign⁴ is helpful only if grossly abnormal, and that a significant degree of oligemia may exist in the absence of hypotension, as long as the patient is in a horizontal position. It has been demonstrated that a blood volume deficiency of as much as 1,000 cc. frequently is not reflected by hypotension, a normal, or even an elevated, arterial tension being maintained through compensatory vasoconstriction until possibly the patient is subjected to general anesthesia or to further blood loss during operation, when the blood pressure may precipitously decline. Thus, casualties with wounds suggesting the possibility of significant hemorrhage were customarily given transfusions in the course of their preoperative preparation, notwithstanding a normal arterial pressure. By the same token, the transfusion of patients treated for severe shock was not discontinued promptly upon restoration of a normal pressure, but, unless specifically contraindicated, an additional amount was supplied on the assumption that there probably still existed a blood volume deficit of between 500 and 1,000 cc.

The presence of sustained hypotension in recently wounded battle casualties was accepted as evidence of severe oligemia and transfusion therapy applied accordingly. Blood volume measurements have shown that the blood volume deficit in cases of

this type, with systolic pressures less than 85 mm. of mercury, almost always exceeds 1,200 cc.¹ Unfortunately, from the standpoint of simplified therapeutics, hypotension is also a feature of severe infection, uncomplicated by oligemia, and may frequently be a deceptive finding in patients with perforating abdominal wounds and peritonitis. This type of shock, of course, is not improved by transfusion, despite which these patients occasionally received excessive amounts of blood and plasma on the erroneous assumption that the circulatory failure was attributable to an inadequate blood volume. Hypotension, in the absence of oligemia, is likewise commonly associated with prolonged anoxemia and central nervous system injuries, and was therefore occasionally responsible for injudicious management in patients with wounds involving the lungs, brain and spinal cord.

Certain other clinical signs, although in general less reliable than the blood pressure as indices of blood volume deficiency, proved of some value in the regulation of transfusion therapy. The trend of the pulse rate, the temperature and color of the skin, and the degree of venous distention occasionally provided confirmatory evidence, either of adequate response to treatment or of progressive circulatory failure. These circulatory manifestations, however, were subject to numerous influences having no bearing on the transfusion requirements, such as prior exposure to heat or cold, the temperature of the immediate environment, pain, the emotional status of the patient, or physiological disturbances arising as a result of anoxia or infection. The degree of anemia and hypoproteinemia were useful only to a limited extent within the first few hours after injury, so slow is the progress of spontaneous hemodilution following hemorrhage. However, the finding of any degree of anemia within a few hours after injury in a casualty who had received no plasma, or the discovery of anemia that was disproportionally marked in consideration of

the amount of plasma that had been transfused, provided strong confirmatory evidence of significant blood loss.

COMPLICATIONS OF TRANSFUSION THERAPY

Excessive Transfusion. The use of excessive volumes of blood and plasma, resulting in pulmonary congestion and edema, was a fault most likely to occur in treating patients who exhibited a low arterial pressure from causes other than oligemia, such as peritonitis, anoxemia, and sympathetic nervous system paralysis following head or cord injuries. This therapeutic error appeared to be especially hazardous when it occurred during the course of general anesthesia. Unusual caution was necessary in treating patients with severe oligemia who had been in shock for many hours. In cases of this type, not only was there an increased susceptibility to the development of pulmonary edema with restoration of the blood volume but, because the arterial pressure responded sluggishly or failed to respond to transfusion therapy, one was tempted to carry this procedure to excess, on the basis of a mistaken diagnosis of continued bleeding. Excessive transfusion was extremely dangerous in patients with perforating wounds of the chest and intrapulmonary hemorrhage because of the possible production of increased bleeding and pulmonary edema. Ideally, in these cases, whole blood was employed, unsupplemented, if possible, by plasma; it was given slowly, and the amount injected limited to the minimum required to maintain an arterial pressure of approximately 100 mm. of mercury.

Pyrogenic Transfusion Reactions. Chills and fever, developing within an hour following the infusion, occurred as a complication of at least 2 per cent of blood transfusions. These reactions were frequently accompanied by a fall in arterial pressure. Although inherently benign, they were to be feared in extremely ill patients

already on the verge of circulatory collapse, and without doubt were immediately responsible for a small proportion of fatalities. The incidence of pyrogenic reactions was relatively high in medical installations employing locally prepared transfusion equipment, presumably as a result of inadequate cleansing and sterilization of tubing and glassware. The common technical faults in the preparation of equipment were failure to utilize an effective detergent, such as trisodium phosphate, to insure immaculate mechanical cleansing, and failure to carry out sterilization promptly after cleaning, thereby favoring the growth of air-borne contaminants, which, despite subsequent autoclaving, remain pyrogenic.

A similar type of reaction followed the injection of stored blood, partially hemolyzed as a result of inadequate or interrupted refrigeration during prolonged storage. Hemolysis appeared to be promoted by the settling and packing of red cells, which, sequestered at the bottom of the flask, were isolated from the preservative diluent. It was noted that cellular packing occurred most readily in elongated bottles which were constricted in the midportion; avoidance of the phenomenon depended upon periodic resuspension of the cells by mechanical shaking or by daily inversion of the bottle. Cell-free hemoglobin solution, from which the stroma had been completely removed, did not appear to have pyrogenic qualities and it was therefore considered likely that the stroma of disintegrated erythrocytes was responsible for these reactions, although this relationship was not specifically demonstrated.

Infected stored blood was rarely encountered. Two fatal reactions, manifested by the prompt occurrence of chills, fever and profound collapse, were discovered to be due to gross contamination of the injected blood with an organism of the coliform group, which interestingly enough, not only multiplied abundantly at refrigerator temperatures, but failed to hemolyze

the stored blood, points of considerable practical importance.

The age of stored blood, barring the occurrence of hemolysis, did not appear to be a factor in the incidence of pyrogenic reactions. Moreover, the survival of transfused erythrocytes, estimated on the basis of Ashby counts performed on recipients with blood groups other than group O, proved satisfactory when stored blood was used within the prescribed time limits (fourteen to eighteen days), provided adequate refrigeration had been maintained throughout the entire period of storage. Unfortunately, once the material had been distributed from the blood bank depots, it too often was exposed to marked temperature fluctuations for several days so that the blood became prematurely aged prior to use. Field medical installations were not equipped with constant temperature refrigeration units; moreover, it was common practice on the part of these hospitals, on moving to a new location, to transport a supply of blood for immediate use on arrival, and during such movements, which occasionally entailed from twelve to forty-eight hours, refrigeration was usually discontinued altogether. The use of ice containers, eventually available, obviated this difficulty to some extent. While over-age blood served effectively in restoring blood volume and supplying a transient increase in oxygen capacity, and could be transfused, unless hemolyzed, without undue risk of untoward reactions, the duration of red cell survival after injection was relatively brief. The average rapidity of red cell destruction in the case of ten to fourteen-day old blood, administered soon after its receipt from the blood bank distributing center, was found to approximate 30 per cent during the course of the first three days, after which the rate of disappearance declined. This, of course, is in sharp contrast to the expected survival of fresh blood, a study of which indicated losses in the recipient of as little as 10 per cent after two weeks; it is significantly

more rapid than the rate of destruction of two-week old blood stored under strictly ideal conditions from the time of collection to the time of injection. Nevertheless, it represents a marked improvement over prematurely aged blood, the storage of which involved prolonged lapses in refrigeration or deleterious packing. The red cells from such blood in some instances were destroyed within three days, as much as 50 per cent occasionally disappearing from the recipient's blood in the course of twelve to twenty-four hours.

Hemolytic Transfusion Reactions. All stored blood distributed by the blood bank depots, representing most of the blood used in treating battle casualties, was of blood group O. The exclusion of bank blood of other groups was a wise precaution in view of combat conditions, for it obviated the necessity for time consuming compatibility tests in advance of each transfusion (a precaution which certainly could not have been dispensed with, for errors in blood grouping, recorded on identification tags, were encountered in as many as 10 per cent of soldiers.) Errors on the part of the blood bank, in the grouping of donor blood, were reported with extreme rarity, approximately five instances having been noted throughout the entire European campaign in which this blood was misrepresented as group O. How many fatal transfusion reactions were due to undetected major group incompatibility of fresh or stored donor blood is unknown.

Reactions due to Rh sensitization undoubtedly occurred, but there was little opportunity for its demonstration. Few hospital units possessed anti-Rh serum for the grouping of recipient or donor blood, and adequate sensitization tests had not as yet been described.⁴ It is probable that in actuality clinical reactions due to the use of Rh positive blood in sensitized Rh negative recipients were rare occurrences in the preliminary overseas treatment of battle casualties, whose transfusion therapy was ordinarily completed within the time required for the develop-

ment of anti-Rh agglutinins. It is to be expected, however, that a certain proportion of Rh negative soldiers, having received Rh positive blood, will have demonstrated subsequent evidence of sensitization, a problem which merits serious consideration by physicians responsible for their later care, should the latter include further transfusion therapy.

Another type of hemolytic transfusion reaction in which, not donor, but recipient red cells are destroyed, occurred following injection of group-O blood containing a high concentration of isoagglutinins which were incompatible with the erythrocytes of the patient.^{5,6,7} This was manifested clinically by chills, fever, transient hemoglobinemia, occasional hemoglobinuria and moderate icterus. The reaction was not uncommonly observed in patients whose blood groups were A, B or AB, receiving group-O blood with a titer of anti-A or anti-B isoagglutinin in excess of 1:500.⁸ Titers of this magnitude are found in less than 0.5 per cent of group-O donors; however, since the majority of seriously wounded casualties received blood from numerous donors, and since group-O blood was employed almost exclusively, this type of reaction was relatively common, comprising approximately one-half of all pyrogenic reactions observed in one series of over 500 consecutive blood transfusions. It did not appear to give rise to serious sequella, apart from those associated with the occurrence of chills and pyrexia, from whatever cause, in dangerously ill patients. Neutralization of the isoagglutinins in group-O donor blood by the use of type specific substance⁹ was not attempted; however, late in the course of the war, blood distributed from the United States was screened with respect to isoagglutinin titer and high-titer blood designated for exclusive use in patients of blood group O.

A variant of this phenomenon, and one which appears to be fundamentally of greater importance than the overt type of hemolytic reaction, was the asymptomatic

blood destruction caused by the transfusion of blood or plasma containing incompatible isoagglutinins. This complication, detected in the course of studies employing serial Ashby counts and measurements of the blood volume,⁸ appeared to have been a common occurrence in patients belonging to blood groups other than group O who received group-O blood or pooled plasma in very large quantities, especially when administered in the course of numerous repeated transfusions. Clinically, this complication was usually manifested solely by the development of mild icterus and an unexplained failure of anemia to improve with successive transfusions. Through laboratory investigation it could be shown that, whereas the donor red cells survived as expected after transfusion, the red cells of the patient diminished in number, and the surviving recipient cells often exhibited an increase in osmotic fragility, effects which were demonstrable to an increasing extent immediately following each successive infusion. Cases were observed in whom, following a succession of transfusions of this type, practically all of the recipient red cells were destroyed, only donor cells remaining. Of a series of patients, other than of blood group-O, who repeatedly received massive amounts of pooled plasma in the treatment of extensive burns, all exhibited these phenomena in varying degree, and in two cases demonstrating progressive fragility changes there developed an acute fulminating hemolytic anemia with hemoglobinemia, hemoglobinuria and almost complete destruction of the recipient red cells. No similar effects were noted in burned patients whose blood group was O, despite the administration of similar quantities of plasma. Thus, an additional argument is provided to substantiate the thesis¹⁰ that whole blood (of homologous group), rather than plasma, is indicated in the treatment of burn shock. There is ample evidence, both from blood volume measurements and in view of the anemia which characteristically

develops, irrespective of blood group and independently of plasma infusions, that a considerable red cell destruction is caused by thermal burns, although masked by a disproportionate loss of plasma. Despite the finding of an elevated hematocrit reading a marked oligemia may be present, for the correction of which the use of whole blood is not only justifiable but probably preferable. There is no physiologic disadvantage deriving from the presence of erythremia per se; from evidence available from physiologic studies¹¹ and from observations of cases with primary polycythemia, the arterial oxygen saturation should remain unchanged and the oxygen capacity of the blood become increased, which could be regarded as of possible benefit.

Repeated transfusions of pooled plasma employed for nutritional purposes are likewise regarded as potentially harmful, although to a lesser extent because of the relatively small quantities of plasma employed, excepting in cases in which the blood group of the recipient is "O." The same objection applies to the use of group-O blood in the routine treatment of anemia in patients of blood groups A, B, or AB. Although the repeated transfusion of "universal donor" blood very rarely gives rise to serious complications and does provide an added source of available iron, it must be regarded as an uneconomical procedure at best, failing, as it does, to accomplish satisfactorily the ends for which it is designed.

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THE factors producing shock, whether primary or secondary, cause undue stimulation of the sympathetic nervous system. The function of the sympathetic nervous system is to maintain the blood pressure and increase the rate of the heart beat.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams and Wilkins Company).

PENICILLIN AND ITS USE IN THE WAR WOUNDED*

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THERE is fairly general agreement among surgeons of experience in the forward area that no drug can be substituted for competent surgical management of wounds. There is also wide acceptance of the essentiality of whole blood for resuscitation in anticipation of blood loss during indicated surgical procedures. Such concepts inherently assign a tertiary and adjuvant status to chemotherapy. Alterations in the practical philosophy of wound management and in the quality and quantity of resuscitating infusions constantly introduced new variables in the program of wound management. For these reasons, it is unlikely that any completely satisfactory statistical analysis of the rôle of penicillin in military surgery can ever be prepared.

The British observations¹ upon the extraordinary efficacy of penicillin in certain established infections were widely confirmed in this country in 1943.¹⁰ The drug was in short supply throughout the greater part of that year. This limited quantity of penicillin restricted military exploitation of the drug to investigative programs. The British Army adopted a plan of local treatment in recent wounds with the hope that serious infections might be prevented in large numbers by a small quantity of penicillin. The American policy reserved the drug for systemic administration in patients with established infection. Overseas distribution was designed initially to provide treatment for life-endangering infections, and the Zone of the Interior was assigned responsibility for the treatment of chronic suppuration. At the time these divergent policies of the British and American armies were announced, both seemed to be acceptable programs

for using the limited supply of penicillin. The subsequent course of events revealed that these early policies exerted a profound effect upon developments in the philosophy of wound management. British surgeons focused their attention upon the bacteriologic sterilization of wounds, whereas American surgeons were compelled to rely upon surgical methods in the treatment of impending infection. Important differences of technic were a consequence of emphasis upon routine local therapy or upon a method reserving penicillin for systemic use in established infections.

The early British experience with local applications of penicillin has been reviewed.^{4,9,20} Soft part wounds were dusted with penicillin powder after initial surgical treatment and were subsequently closed secondarily around rubber tubes for instillation of solutions of penicillin. Pleural instillation of the drug was practiced for hemothorax and empyema. Short courses of five to ten days of systemic administration of penicillin were given as a supplement to the local treatment of compound fractures. Tubes were sewed into major joint wounds for irrigation and infusion of penicillin. The net result was a comparatively reduced incidence of infection with pyogenic cocci and a probably reduced incidence of death due to infection. The clinical results won the approbation of many, but by no means all, of the surgeons privileged to review this experience.

The early American experience with penicillin in the treatment of suppurative compound fractures¹¹ established the inability of penicillin to sterilize dead or devitalized tissue. It was also shown that penicillin therapy did not permit the

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immediate surgical closure of wounds after removal of dead tissue in process of septic decomposition by proteolytic bacteria. The most important positive contribution of this study was the demonstration that systemically administered penicillin permitted operative intervention in suppurative wounds at a time of election without danger of exacerbation of invasive infection. Subsequent observations identified the technic of secondary, or delayed, wound closure after sequestrectomy as an acceptable and desirable component of this program of management of suppurating wounds. There emerged a philosophy of wound management defining a healed wound as its objective. Emphasis in the care of the local wound was given to its surgical preparation and secondary closure. Supportive blood transfusions and chemotherapy to prevent invasive infection were assigned essential but adjuvant positions.

As the American supply of penicillin increased in the early months of 1944, quantities became available for expansion of the original overseas program. The tactical situation in the Mediterranean Theater proved ideal for critical appraisal of the proposed plan of wound management. It is historically important that the major effort of this investigation was the clinical evaluation of a philosophy of wound management rather than an appraisal of penicillin therapy. In accordance with the original American policy of reserving penicillin for established infection, it was visualized that chemotherapy should be given for the demonstrated hazard of impending infection rather than as routine prophylaxis. Inasmuch as the experience of World War I had shown the beta hemolytic streptococcus to be the major hazard of infection in cleanly excised soft part wounds, it was believed that these could properly receive sulfonamides alone. Penicillin was reserved for the treatment of complicated soft part wounds and compound fractures. These general considerations have been

discussed in greater detail elsewhere.¹² The fundamental surgical principles adopted were: (1) Early and complete initial surgery, (2) the wound left open and dressed with fine mesh gauze, pressure and splints, and (3) early closure of wounds showing no clinical evidence of infection.

Careful bacteriologic studies in the Italian Theater¹³ demonstrated the susceptibility to penicillin of the invasive bacteria recoverable from war wounds. Other bacteria, lacking invasive attributes, were important as wound pathogens. Among these latter, the *Clostridium sporogenes*, *Pseudomonas pyocyanea*, *Bacillus proteus*, and para-aerobacter organisms were relatively or completely resistant to the action of penicillin. Suppuration associated with these bacteria was a common consequence of devitalized tissue and hematomas retained within a wound in spite of penicillin therapy. It was apparent from these studies that the usefulness of penicillin was limited necessarily to the control of invasive infection.

Toxic *Clostridium* infection has been noted by many observers in patients receiving adequate dosage of penicillin. Hemolytic toxemia with bronzing and evidence of intravascular hemolysis does not appear to have been recognized as a complication of gas gangrene in war wounded. The toxemia observed is attributable to absorption of products of tissue putrefaction. Both devitalized muscle and blood clot appear clinically to possess the essential metabolites for release of this particular toxic factor. It was the opinion of MacLennan and Macfarlane¹⁷ that penicillin contributed to the effective treatment of gas gangrene. Cutler and Sandusky²⁰ reported the occurrence of gas gangrene in five American airmen after initial operation with systemic penicillin therapy. In discussing this report, Garrod⁵ notes, "In some at least of these cases the condition appears to have been inevitable gangrene in tissue deprived of its blood supply, and not active bacterial invasion of healthy muscle: that this was

the condition in Case 2 is clearly evident from a color photograph (Fig. 93)." In an analysis of 185 cases of gas gangrene treated with penicillin, Macfarlane¹⁵ observed a statistically significant reduction in mortality for infections of the leg or arm. Infections in the thigh, buttock, and shoulder showed a persistent mortality of 40 per cent. The only variable in these two groups was the surgical accessibility of the infected muscle groups. Penicillin is effective in lowering mortality in gas gangrene after adequate excision of devitalized tissue, but is relatively ineffective without such supportive surgical excision. This final appraisal of penicillin therapy for gas gangrene received British²² and American¹⁹ concurrence.

In experimental studies,^{6,18} the superiority of penicillin over other antibacterial agents was clearly shown. It was noted in these experiments that a barrier of fibrosis formed at the junction between devitalized and living tissue. The usefulness of penicillin to protect living tissues from invasive infection has been confirmed by clinical observation. Acceptance of this point of view is fundamental in establishing the systemic route as the administrative method of choice.

Devitalized tissue or hematomas permit the development of anaerobic infection. Penicillin, either locally or systemically, has not been demonstrated to prevent the ultimate septic decomposition of contaminated and devitalized tissue. It has been concluded that the local administration of penicillin is better than no chemotherapy at all,² but this study did not contrast local and systemic therapy. There is an increased incidence^{11,16} and hazard¹³ of infection with wound pathogens as a complication of local penicillin therapy. Local therapy is ineffective in a wound containing dead tissue and is not necessary in a clean wound. The greater effectiveness of systemic therapy has been recognized in American and British directives prescribing systemic treatment for complicated wounds and compound fractures.^{19,21,22}

In conclusion, the British investigators demonstrated the antibacterial properties of local penicillin therapy in war wounds, whereas American investigators used systemic therapy to develop a new philosophy of wound management. This development was recorded by Churchill³ and is currently in process of elaboration by surgical specialists relieved from active overseas assignments. In the main, these principles of wound management found British acceptance in Italy.¹⁴ However, the evaluation of penicillin therapy for the war wounded demands a familiarity with both British and American experiences. Penicillin seems to have been partly responsible for improved results in surgical management. The improvement noted does not imply superior accomplishment in contrast with individual results achieved in World War I. It does recognize a high level of surgical achievement by all surgeons under a variety of tactical situations. Penicillin gave assurance that infection could be localized to the suppuration of devitalized tissue and blood clot and directed attention to the early closure of war wounds. This is most strikingly attested by comparison of the early pessimism⁷ and the later enthusiasm⁸ for the reparative surgery of compound fractures expressed by Hampton. On this basis, penicillin is today the most acceptable antibacterial agent available as an adjuvant to surgical management of the war wounded. The preference for systemic chemotherapy and the abandonment of local applications have been dictated by the philosophy of wound management evolved to afford the best care to the largest number of casualties.

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THE FUNCTION OF THORACIC SURGERY CENTERS IN WORLD WAR II

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THE policy of concentrating surgical cases in centers manned by personnel with special training for the problems involved was instituted by the Surgeon General in the early years of World War II. Among the centers designated for special care of surgical patients were five thoracic Surgery Centers in the Zone of the Interior.

During the last war, cases of suppurative pleuritis were segregated in a few hospitals but were usually under the auspices of the Septic Surgery Section. With this one possible exception surgical chest cases were included in general surgery and no specialization was employed. Moreover, twenty-five years ago there were few surgeons qualified or interested in limiting their activities to surgical diseases of the chest.

The concentration of patients with thoracic wounds and diseases of the chest has made possible technical advances in chest surgery and, more important, has afforded opportunities for comprehensive statistical studies involving both wounds and diseases of the chest. Five Thoracic Surgery Centers were established in general hospitals in the United States.* The purpose of this paper is to outline briefly the various problems encountered in a large Army Thoracic Surgery Center.

The advantages of the Center System are obvious. Opportunities for the concentration and conservation of specially trained personnel, including surgeons, nurses, physiotherapists and corpsmen provide superior facilities for diagnosis and treatment. Moreover, there are many problems in the treatment of thoracic sick and wounded which are unique. Not only surgical tech-

nic and anesthesia are somewhat different than those encountered in general surgery, but preoperative and postoperative care are highly specialized. Tremendous advances in physiotherapy and reconditioning of patients with thoracic wounds and injuries have been made during the past few years. Opportunities for the study of unusual numbers of tumors of the mediastinum, chest wall and lung have been possible. Suppurative diseases of the lung, including large numbers of cases of bronchiectasis, lung abscess and pulmonary cysts were seen and war wounds resulted in many cases of empyema, chronic draining sinuses, hemothorax and retained foreign bodies in the chest.

The Walter Reed General Hospital was one of the five Thoracic Surgery Centers established in the United States and a study of the admissions to this Center will serve as an index to the types of cases seen and the general principles of therapy employed in all Centers. The Chest Centers received thoracic sick and wounded from every part of the world where American troops are stationed. The deployment of cases to Chest Centers was from three main sources: First, battle casualties and patients who had contracted thoracic diseases while on overseas duty. These patients were ordinarily returned by the usual chain of evacuation and screened at the port of debarkation. A second important source of admissions was from Army dispensaries, station hospitals and regional hospitals throughout the United States. The third source which contributed to the majority of tumor cases was patients who were found to have intrathoracic neoplasms detected by roentgen examination, either at the time of induction into the military service or later when a roentgenogram of

* Baxter General Hospital, Spokane, Washington, Brooke General Hospital, San Antonio, Texas, Fitzsimons General Hospital, Denver, Colorado, Kennedy General Hospital, Memphis, Tennessee, and the Walter Reed General Hospital, Washington, D.C.

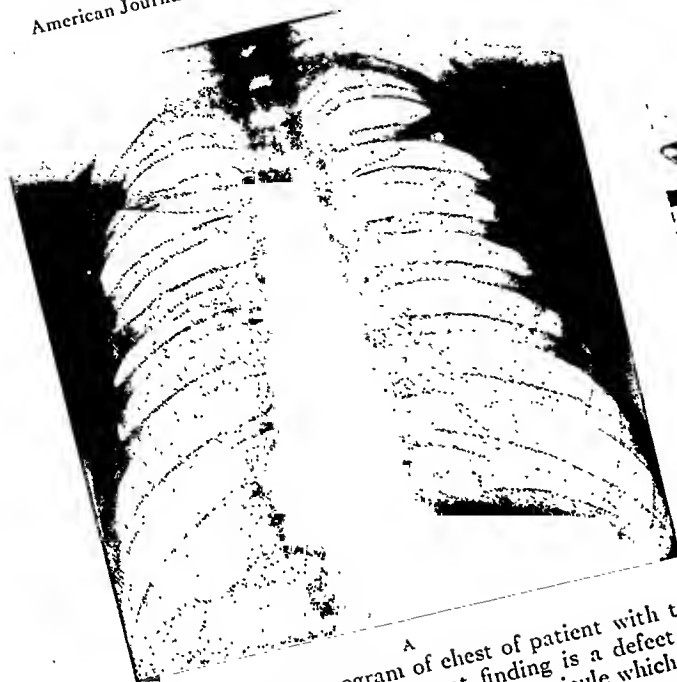


FIG. 1. A, roentgenogram of chest of patient with two-inch spicule of rib in lung. The foreign body is not visible. The only significant finding is a defect of the left sixth rib which suggested an old injury. B, roentgenogram of resected rib and spicule which was penetrating the underlying lung.

the chest was made before the individual was separated from the service. The amazing number of potentially dangerous neoplasms which were detected by routine roentgenograms demonstrates clearly the advantage of this method of examination.

Important types of cases fall into three main groups and their subdivisions, namely, battle casualties, suppurative diseases of the chest and tumors of the chest.

Battle Casualties. Approximately 75 per cent of patients with battle wounds were well when they reached Thoracic Surgery Centers in the Zone of the Interior. The severity of their wounds and uncertainty of the ability of the patient to perform full military duty justified evacuation to the United States. The high percentage of cures in this group reflects the splendid care which they received at field and rear echelon medical facilities overseas. The patients who required further treatment included instances of retained foreign bodies, chronic hemothorax, chronic empyema, various chest wall defects, including chronic draining sinuses, bronchopleural fistulas, deforming scars, rib defects and hernias of the lungs.

Suppurative diseases of the lung, namely, bronchiectasis, lung abscesses, pulmonary cysts and chronic infectious granulomas, constituted a main problem. And many tumors of the lung, mediastinum and chest wall have been observed and treated. It is not within the scope of this paper to discuss the relative frequency of various thoracic diseases or to describe in detail the treatment. Only points of general interest will be considered.

Intrathoracic Foreign Bodies. Retained intrathoracic foreign bodies have been frequent and interesting problems. Shell fragments, bullets, bits of clothing and wooden splinters have been removed from the lung, mediastinum and chest wall.

The initial and most important problem in the management of foreign bodies of the chest is whether or not the foreign body should be removed. It has been necessary to follow certain general but not absolute indications to determine this problem.

1. *Type of foreign body:* It is generally agreed that non-metallic foreign bodies, e.g., clothing, wood, etc., should be removed. Unfortunately, clothing and other foreign material which may be carried into

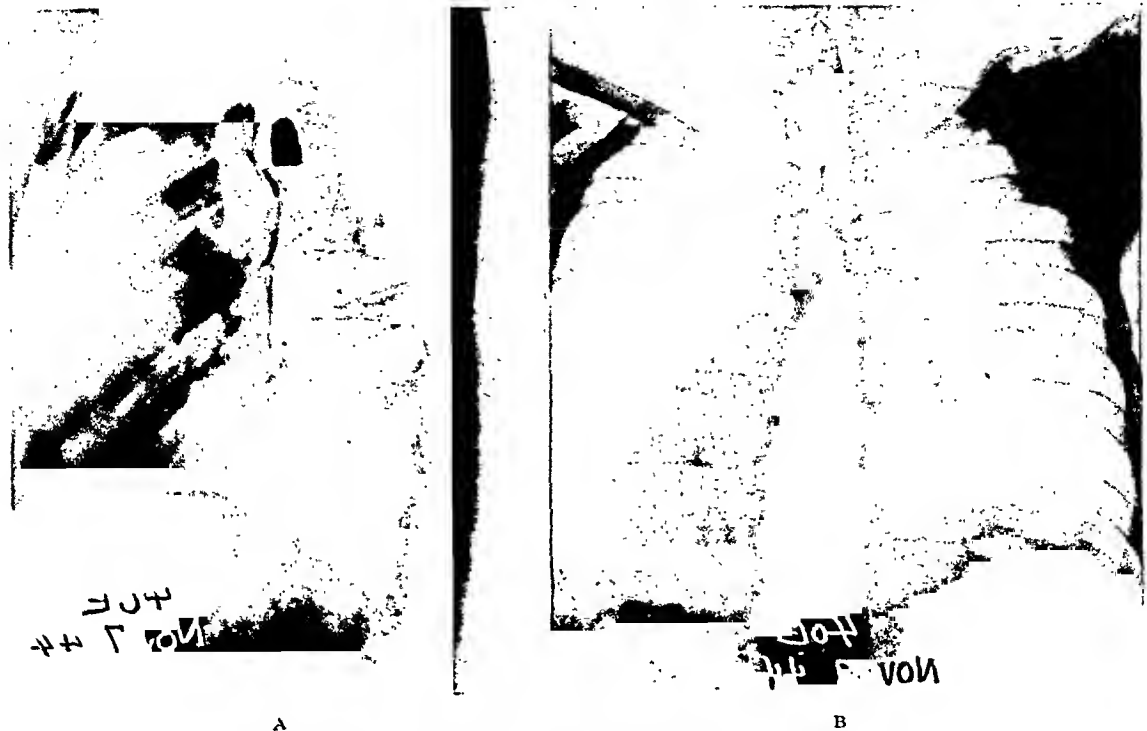


FIG. 2. A, roentgenogram of chest showing esophagus visualized with barium and position of a 45 caliber bullet immediately posterior to the organ. B, anteroposterior view of the same patient.

the body with shell fragments or bullets may cast little or no shadow on an x-ray film. Even spicules of bone in the lung parenchyma are difficult to localize or identify. If, however, the presence of a nonradio-opaque foreign body is suspected exploration of the chest is in order. (Fig. 1A and B.)

2. *Symptoms:* When there are symptoms which may be attributed to a foreign body in the chest, surgical removal is indicated. If the lung is involved, the most common manifestations are pain and hemoptysis. Chest pain, however, associated with the presence of a foreign body is difficult to evaluate. Usually the pain is the result of injury to the chest wall. The sensory nerve supply to the pulmonary parenchyma is practically negligible; it is apparent, therefore, that pain originating from intrapulmonic foreign bodies results from injury to the pleura or elements of the chest wall.

3. *Size:* Attempts to establish the relationship between the size of retained foreign bodies in the lung and possible future prognosis have not been conclusive. Whether such a relation exists is problematical. Nevertheless, it has been necessary

to establish an arbitrary limit on size of foreign bodies as an indication for surgical intervention. Radio-opaque foreign bodies, in which the greatest diameter exceeds 2 cm., have been considered large enough to warrant operative removal.

4. *Position of foreign bodies:* In certain cases foreign bodies which would not ordinarily be disturbed on the basis of size alone, were removed because of their position. This is true particularly when the fragment is intimately associated with important structures in the chest, namely, the great vessels, mediastinum and heart. It should be emphasized, however, that unless the foreign body was of a good size this indication for surgical removal was handled very conservatively. (Fig. 2A and B.)

5. *Psychosomatic factors:* Patients who have been informed of the presence of a retained foreign body often develop anxiety states. This is true particularly when the foreign body is in the chest. In some instances these patients are insistent to the point of obsession in requesting surgical removal. Occasionally, this factor alone justified operative interference.

Methods of Localization of Foreign Bodies. The precise localization of a retained shell fragment or spicule of bone in the thorax may test the ingenuity and patience of the surgeon and radiologist.

Roentgenograms. The routine use of the frontal and lateral projections of the chest will furnish a three dimensional concept of the thorax which localizes with reasonable accuracy an opaque foreign body. Examinations with the fluoroscope and oblique projections of the chest are useful and are of particular value when the foreign body is in intimate contact with mediastinal structures. Fluoroscopic examination will usually aid in establishing whether or not the fragment is in the chest wall or in the lung parenchyma and if the foreign body is in or near the pericardium or myocardium the motion of the fragment with the cardiac impulse will be established.

Angiocardiograms. Angiocardiogram technic employed at Walter Reed General Hospital was instituted by Lieutenant Colonel George P. Robb, Chief of the Cardiovascular Section. A brief description of this procedure is given to illustrate the value of the angiocardiogram in the accurate localization of foreign bodies that are in intimate contact with the vessels of the mediastinum. This procedure is divided in two stages, the first stage being the determination of the circulation time from the arm to the tongue and the arm to the lung. Arm to tongue circulation is determined by the injection of ceecholin sodium solution and the accurate stop watch measurement of the elapsed time between injection and onset of bitter taste. The arm to lung circulation time is also obtained if the circulation time exceeds a certain value. This latter procedure consists of measuring the elapsed time between injection of an ether solution and when it is first detected on the patient's breath. When these time factors are determined, a second stage is then carried out by positioning a patient before a stereoscopic cassette. The angiocardiograms are then obtained by the introduction of diodrast concentrated

solution into the veins. This radio-opaque medium does not disseminate immediately in the vascular system. Instead the rapidly injected diodrast forms a "bolus" which may be followed from its point of injection through the cardiovascular system until it is broken up in the peripheral vessels. By careful evaluation of the circulation time, which has been previously determined, the approximate time of opacification of the intrathoracic cardiovascular system can be obtained. In this way separate roentgenograms can be made showing contrast filling of the right ventricle and pulmonary arterial tree, then the left ventricle and aorta. In the same way the superior vena cava and the right auricle are opacified at different times than the pulmonary veins and the left auricle. The information obtained from this procedure is precise and it is often possible to get an almost exact location of the mediastinal foreign body in relation to the mediastinal-cardiovascular system.

Opaque Markers on Chest Wall. Some surgeons employ various markers on the chest wall. Small bits of metal may be taped to the chest wall after the foreign body has been localized by fluoroscopic examination. The position of the marker may then be checked by the use of roentgenograms taken in appropriate positions. Another technic which has been used, both for localization of foreign bodies and pre-operative localization of lung abscess, is to inject a few cc. of dye, either methylene blue or gentian violet mixed with lipiodol, into the chest wall at the site where the intrathoracic lesion is in contact or nearest to the chest wall. This furnishes both a visible and radio-opaque landmark for the surgeon.

The Berman Locator. The Berman Locator first received considerable publicity when it was used by Dr. John Moorhead at Pearl Harbor. This instrument has proven to be a valuable adjunct in the localization of magnetic foreign bodies, particularly when the foreign body is deeply located in the lung parenchyma and mediastinum.

The Berman Locator has a long handled probe which may be sheathed in a sterile rubber casing and cloth sleeve. With this protective covering, it may be used to explore any cavity that is entered surgically. As contact with a metallic foreign body is made by the tip of the probe, a constant sound vibration is heard. This sound varies in volume directly in proportion to the distance between the probe and the foreign body. When the Berman Locator is properly used, the operative removal of magnetic foreign bodies is greatly facilitated. It should be considered, however, strictly as an adjunct to surgery. In the hands of an untrained operator it will offer nothing more than a false sense of security that is readily demonstrated when the thorax is explored.

The Foreign Body Register. The fate of retained foreign bodies is not entirely understood. Although numerous papers have been written on military surgery relative to this subject, the evidence is still inconclusive. No one knows whether or not all foreign bodies of the lung should be removed. There is no assurance that a currently asymptomatic foreign body will not cause trouble later. Operation was not advised in many of the cases of retained foreign bodies seen at Walter Reed General Hospital. In many of these cases the missile appeared to be clinically quiescent and for one or several reasons was not disturbed. All of these patients have been recorded in the Foreign Body Register. Periodic surveys will be made at intervals in an effort to determine the eventual outcome of this group. If the Register succeeds in its purpose, a large amount of pertinent information will be available in future years.

CHRONIC HEMOTHORAX

Perhaps the most interesting cases returned from overseas theaters have been those with chronic hemothorax. Since hemothorax is an almost expected complication of wounds penetrating the pleural space, the incidence of this entity was high.

The management of the acute phase by early and complete aspiration of the chest was instituted in front line hospitals. It may be stated here that aspiration without air replacement was the general policy in therapy. Only a small percentage of the acute cases progressed to the chronic phase. These comparative few required radical surgical intervention to effect a cure.

Treatment of Chronic Hemothorax. Usually more than eight weeks had elapsed from the time of injury until the patient returned to the United States. Thoracentesis was no longer of value because of the extensive organization of blood clots. With few exceptions these patients were treated by exploratory thoracotomy. An overlying rib was resected and the cavity opened widely by means of a rib spreader. After all organized clots and liquid were evacuated, a careful inspection of the cavity was made. An excellent article on this subject by Burford et al. has described the technic of decortication in chronic hemothorax and postoperative empyema. Burford also notes that the optimum time for decortication seems to be between six and eight weeks after the development of the hemothorax. This optimum time refers to that period when a good "peel" is most easily developed. It is of interest to record that many cases at Walter Reed General Hospital were treated by decortication as late as six months after being wounded and did very well. The opinions of surgeons at this hospital in general support that of Burford and his associates, but we do believe that decortication is still of value many months after the optimum period has elapsed. (Fig. 3A and B.)

CHRONIC EMPYEMA

Chronic empyema resulting from war wounds has been the most common and the most serious chest complication treated in the Thoracic Centers in the Zone of Interior. In spite of the universal use of chemotherapy in the management of war wounds, an important incidence of chronic suppurative pleuritis has persisted. In the

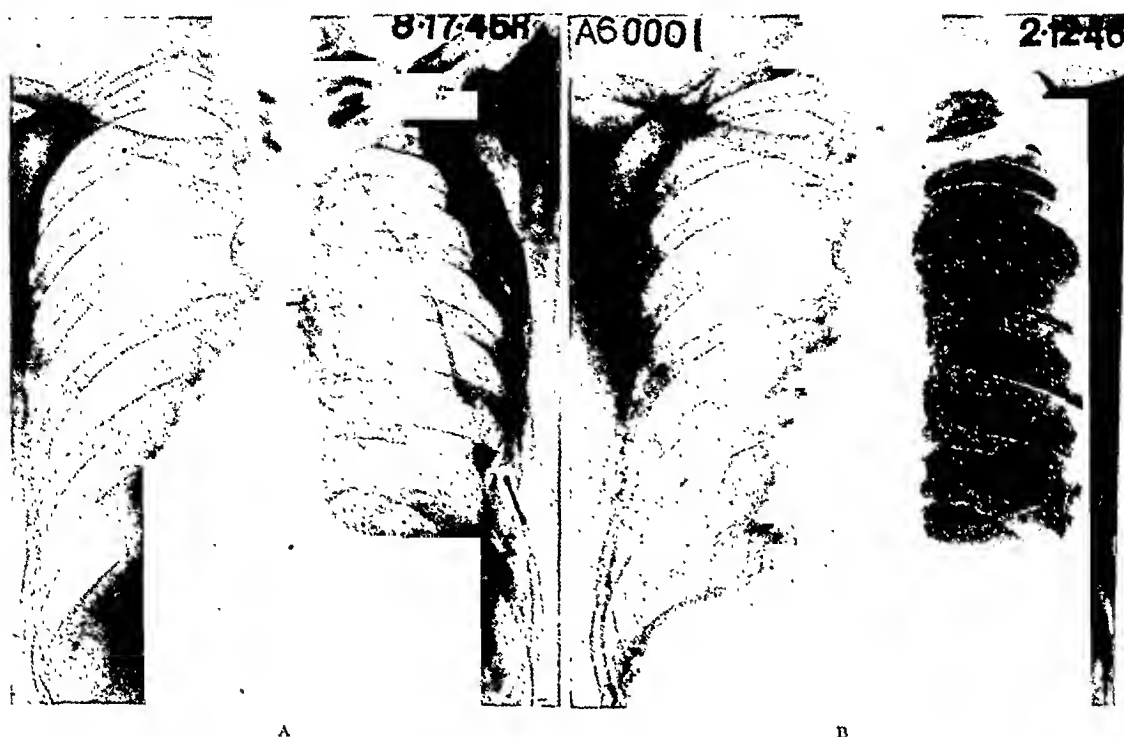


FIG. 3. A, roentgenogram of the chest showing chronic empyema which resulted from an infected hemothorax. The chest has been adequately drained by open thoracostomy. B, roentgenogram of chest six weeks after decortication operation for chronic empyema. This case illustrates the possibilities for restoration of lung function, obliteration of chronic empyema and conservation of the chest wall in patients who have had preceding injury.

majority of cases, the disease has been secondary to an infected hemothorax. Patients with empyema have usually been treated in rear echelon hospitals before evacuation to the United States. On arrival at the port of debarkation the patients with empyema have been given high priority. These patients were usually sent to a Thoracic Center even though other unrelated diseases may have been present that required specialized care.

Treatment of Chronic Empyema. The most common method of treatment of chronic empyema in overseas theaters involved dependent open drainage. This procedure was primarily designed to prepare the patient for evacuation to the Zone of the Interior. In the early phase of the war an occasional patient returned with closed intercostal catheter drainage. These patients were definitely in the minority and presented real evacuation problems because they were burdened by portable water bottles that dangled between their knees.

In the last year of the war closed seal drainage was seldom seen. The overwhelming majority of surgeons used open tube drains in the dependent part of the empyema cavity.

Upon admission to Walter Reed General Hospital, the general conditions of patients with empyema thoracis were carefully evaluated. Since most of these patients reflect the effects of chronic sepsis and general debilitation, immediate treatment involved general physical rehabilitation. The first step in this procedure was careful physical inspection of the patient and admission x-rays to determine the adequacy of drainage. Frequently, the initial surgery had been conservative and it was necessary to revise the thoracostomy wound to provide adequate drainage. In many cases this simple revision operation, coupled with intensive specialized physiotherapy, would be enough to accomplish complete obliteration of the cavity. Even if a cure was not obtained, the patient's

general physical condition was invariably benefited to a marked degree. After these simple procedures had been performed and the patient allowed time for general improvement, he was considered for further surgical procedures of a more radical nature. Generally, a simple rule was followed as an indication for surgical correction of a chronic empyema cavity. If a well drained empyema cavity shows no reduction in size after a period of six weeks, the patient was considered a candidate for surgical intervention. In this connection it is important to emphasize that the only reliable method for determining an empyema cavity is by accurate measurement with fluid. The only valid reason to omit the measurement of an empyema cavity with fluid is the presence of a bronchial fistula. The introduction of any fluid in this type of case is potentially dangerous.

Several procedures were employed in the treatment of chronic empyemas. In all cases a decortication operation was attempted when large cavities were present. Frequently, this procedure has been very successful and has afforded the patient a complete cure. This procedure is very similar to that described by Burford and his associates in almost every detail. In some cases, however, the thickened membrane on the visceral surface of the empyema cavity was not amenable to decortication and a procedure of second choice was employed. The term "internal pneumonolysis" was used at Walter Reed General Hospital to describe this operation. Actually this is not a very descriptive term and a brief explanation of the technic may be of interest. The operation is only employed when decortication is abandoned because a "peel" is not obtained. Briefly, this procedure is initiated in the same manner as a decortication operation by resection of a rib and wide exposure of the entire empyema cavity. When the "peel" cannot be removed from the underlying pleura without damage to pulmonary tissue, the pneumonolysis is carried out by carefully incising the membrane around the

periphery of the empyema cavity. This incision is carried through the membrane where the parietal and visceral portions conjoin. The visceral portion is left adherent to the underlying lung and the surgeon then carefully frees the lung from the non-involved portion of the thorax. This latter procedure is usually easily done by blunt dissection, using the gloved fingertip or dissecting sponge. After dissecting free the underlying lung, positive pressure is then carefully applied and the lung is re-expanded. As the partially collapsed lung is re-expanded, it usually fills the entire chest cavity and the empyema space is obliterated. Closure is similar to that of a decortication operation. This procedure is of real value in that it often obviated thoracoplasty and is not in itself a deforming operation. (Fig. 3A and B.)

The importance of adequate physiotherapy in the treatment of chronic empyema cannot be overemphasized. A competent physiotherapist trained in problems of chest diseases can do an inestimable good in helping the patient acquire maximum re-expansion of the lung and in overcoming chest wall deformities that are commonly seen in chronic empyema.

CHEST WALL DEFECTS

The remarkably low incidence of serious chest wall defects in the many war casualties of the thorax can be at least partially explained by the splendid emergency treatment wounded men received. The control of secondary infection by adequate surgery and chemotherapy practically eliminated the ghastly sloughing wounds of the chest wall common twenty-five years ago. When serious defects of the chest wall were encountered it was almost always possible to effect a satisfactory repair with the skin, muscle and bone of the thorax. In a few isolated instances tantalum plates were employed to bridge the defects in the chest wall. These endeavors were commonly disastrous. The tantalum plate acted as a foreign body and either sloughed out or had

to be removed. True hernias of the lung are relatively rare.

BRONCHIECTASIS

Of the chronic suppurative diseases of the chest diagnosed at Walter Reed General Hospital, the large majority were bronchiectasis. This entity proved to have an unexpectedly high incidence in the armed forces. In the years of 1942 and 1943 no less than 3,777 cases of bronchiectasis were admitted to Army hospitals. Even if one assumes that many patients did not have true bronchiectasis, it becomes apparent that the disease constituted a real problem. All of these men had passed induction examinations, including roentgenograms of the chest. This knowledge makes us wonder how many undiagnosed cases there must be in the general civilian population today. The diagnosis of bronchiectasis ultimately depends on a bronchogram. We can assume that many more patients were incorrectly diagnosed because facilities for lipiodol instillation into the tracheobronchial tree are not available at all Army installations.

All types and degrees of bronchial dilations have been seen. The majority of patients had unilateral disease and could be treated successfully. In some instances patients with bilateral disease were benefited by surgical therapy. The only really satisfactory treatment for bronchiectasis is surgical extirpation of the diseased tissue.

Treatment of Bronchiectasis. In the Army the policy was to discharge those patients who would not submit to operation or who were not amenable to surgical treatment. The diagnosis was suggested by clinical manifestations but was always confirmed by bronchography. Those patients who refuse operation or who have extensive bilateral disease are given medical discharge from the service. Advanced cases who are not candidates for surgery are usually transferred to a Veterans Administration facility for continued hospitalization.

Patients who were operated upon for bronchiectasis showed gratifying improvement. In most cases operation was confined to single lobectomy. Next in frequency were the cases with combined left lower lobe lobectomy and lingulectomy. Less commonly, segmental resections were done when the disease was confined to one segment of a lobe. When a patient had bilateral involvement of his lungs and was still considered a candidate for surgery, two separate operations were performed. Usually the more involved side was operated upon first and the other after an interval of four to six months.

Preoperative Preparation for Lobectomy. Before the sulfonamide derivatives and penicillin were available, the preoperative preparation for lobectomy consisted of careful postural drainage and measures to improve the patient's general condition. The introduction of penicillin has offered great advantages and since this mold has been available it has been customary to perform pulmonary resections with so-called penicillin protection. For the patients at Walter Reed General Hospital, Romansky's technic of administering a single injection of 300,000 units of penicillin in beeswax and peanut oil has been utilized. The penicillin is given from three to seven days before operation and continued until the temperature remains normal after the operative procedure. Another important preoperative measure is the preparation of the patient by the physiotherapist who carefully instructs the surgical candidate on breathing exercises which will be carried out through the postoperative program.

The details of operative technic will not be discussed in this paper; however, a few essential principles will be mentioned. The lobectomies in this series were almost always performed by the ligation of each vessel in the bronchi and the hilum of the lobe rather than with a tourniquet. In all cases of partial pulmonary resection, the pleura is drained by means of an air-tight catheter connected to water seal suction. In most cases the drainage tube or tubes

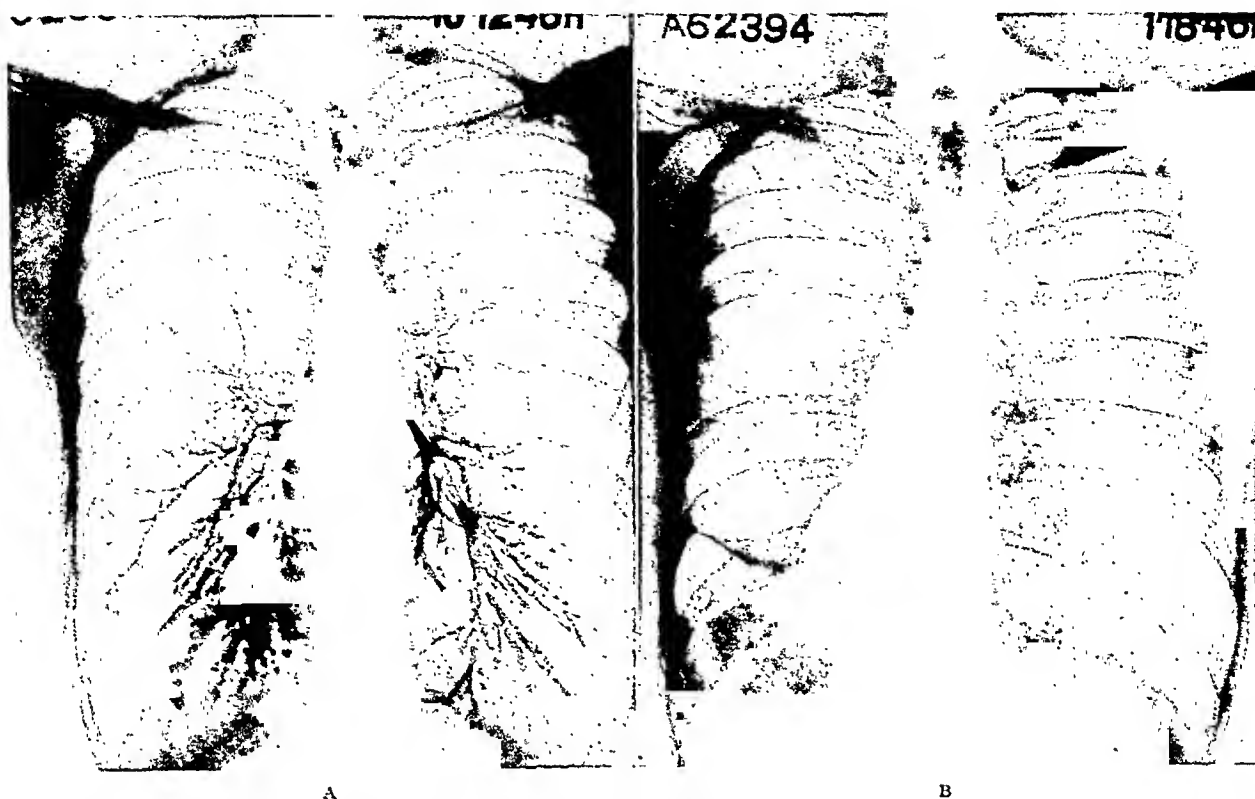


FIG. 4. A, bronchogram demonstrating bronchiectasis of the left lower lobe and lingula of the left upper lobe with minimal involvement of the right lower lobe. B, roentgenogram of the chest twenty-one days following left lower lobe lobectomy and lingulectomy.

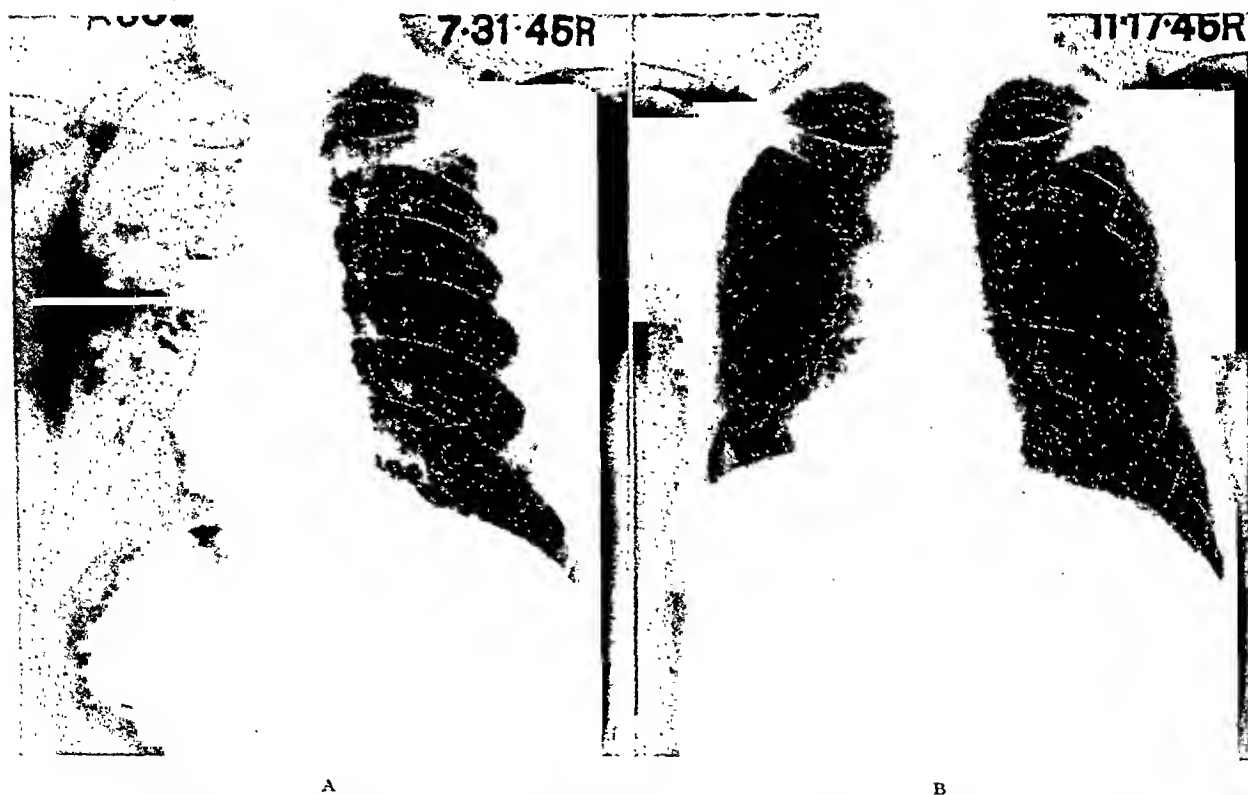


FIG. 5. A, roentgenogram of the chest showing chronic lung abscess in the left upper lobe. B, appearance of the chest six weeks after left upper lobe lobectomy.

are removed in twenty-four to seventy-two hours.

Bronchoscopy is performed routinely in the operating room before the patient regains consciousness. This guarantees the removal of mucus or blood which may have accumulated in the tracheobronchial tree. Following the bronchoscopy, a portable roentgenogram is made in the operating room. If the postoperative roentgenogram reveals atelectasis or unsatisfactory re-expansion of the remaining lung tissue, immediate corrective measures are instituted.

Postoperative Care. Three hundred thousand units of penicillin were given daily during the postoperative period until the patient was symptom free. Daily roentgenograms were taken at the bedside to keep constant check on the expansion of the remaining lobe or segments of lung. Early activity of the patient is encouraged. An effort was made to have the patient dangle his feet in twenty-four hours and get out of bed in two or three days. Many visitors are surprised to learn that the postoperative course of a patient with an uncomplicated lobectomy is as uneventful as of one with a simple appendectomy. When the remaining lung tissue had expanded to fill the hemithorax and the patient's general condition warranted it, he was given a recuperation furlough. Many of these patients returned to full duty following a lobectomy. (Fig. 5A, B and C.)

LUNG ABSCESS

It will be difficult in the final analysis of World War II thoracic sick and wounded to determine the incidence of lung abscess. It is highly probable that the extensive use of penicillin and the sulfonamides has lowered the rate of pulmonary abscesses tremendously. It is likely that many abscesses were detected in the acute phase and cured by adequate chemotherapy and the usual medical régime. Because of this, many patients were treated in smaller medical facilities and never reached the thoracic centers. Only those patients who

developed the chronic lung abscess were transferred to a center. These patients had already received more than adequate amounts of penicillin and sulfonamides and were transferred primarily for surgical consideration.

Treatment of Chronic Lung Abscesses. For many years excisional surgery in the treatment of chronic lung abscesses involved such high mortalities that drainage was usually employed. The incidence of cures obtained by simple drainage of chronic lung abscesses has been low. Too often an entire lobe is destroyed and not infrequently the infection has traversed interlobar fissures invading adjacent lobes. In these cases drainage may possibly improve the condition by decreasing the amount of sputum and perhaps make the patient fever free, but he continues to be a chronic invalid. It is our belief, therefore, that if the lesion is chronic with evidence of multiple consolidation, atelectasis or involvement of an entire lobe, excisional surgery should be recommended. Other reasons for choosing pulmonary resection instead of drainage are persistent serious hemorrhage, either from a drained or undrained abscess cavity, involvement of an entire lobe, particularly an upper lobe, or, if more than one lobe is involved, and the possibility that a neoplasm is the underlying factor.

It is admitted that the operative risk of lobectomy for chronic lung abscess is far greater than lobectomy for bronchiectasis. In our own series of sixteen cases, the operative mortality was 6.4 per cent. It must be emphasized, however, that all of these patients were young and good risks for major operations. Even if one accepts a high operative mortality, a large number of cases may be salvaged by excisional surgery who are otherwise doomed to a life of chronic invalidism.

It is highly important that the lobectomy be performed by the individual ligation technic in an effort to prevent complicating empyema. It is in this group of cases that particularly dangerous putrid postopera-

tive empyemas may develop. (Fig. 6A, B and C.)

CYSTIC DISEASE

A patient with congenital pulmonary cysts does not necessarily have a suppurative process of the lungs. However, such a high percentage of the lung cysts found in Army personnel had become infected that this entity was considered one of the chronic suppurative diseases of the chest. Since cystic disease had been diagnosed by routine roentgenograms in so many of these patients and had no associated symptoms, it is our belief that cystic disease of the lungs will be more frequently recognized in future years. Almost every soldier in World War II was exposed to two or more radiologic examinations of the chest in an average period of less than three years. For this reason there was a comparatively high incidence of diseases that were heretofore considered rare. The recognition rate of cystic disease of the lung will rise with increased roentgen opportunities for the average civilian patient.

The term, cystic disease, as used at Walter Reed General Hospital includes the bronchiogenic cysts. It was believed that all cysts of the lungs and tracheobronchial tree are probably bronchiogenic in origin and have potential or direct communication with the bronchi. Lung cysts which are usually surrounded by parenchyma were frequently thin-walled spaces and easily overlooked on the examination of the roentgenograms. When these cysts became infected, they usually filled with fluid and produced symptoms similar to a lung abscess. Occasionally, these infected cysts were so large that the patient was admitted with the diagnosis of encapsulated empyema.

The bronchiogenic cysts invariably appeared as areas of increased density on the roentgenogram. These cysts were most commonly found in the posterior mediastinal regions associated with hilar structures. Occasionally, however, they were removed from the parenchyma of the lung



FIG. 6. Angiocardiogram showing visualization of the aortic arch and position of metallic foreign body which is embedded in the anterior myocardium.

and not associated with the major divisions of the bronchi. Because of their increased densities, they were frequently mistaken for other benign tumors and, on more than one occasion, for solitary metastasis. At operation, many of these cysts were very thin-walled and filled with fluid. Others had a dense collagenous material occupying the cyst cavity that resembled mucin. The thin-walled cysts that contained fluid were occasionally observed to vary in density when repeated radiologic studies were made. This observation is explained by fluctuation in the contents of the cyst. If a small communication with a bronchus is present, the cyst may expel part of its contents on occasion. This has been demonstrated following bronchoscopy when the patient has had violent coughing.

Treatment of Lung Cysts. Simple lung cysts may be discovered in all age groups. It is obvious that the discovery of a non-infected cyst is not in itself an absolute indication for surgery. All patients with solitary or multiple asymptomatic cysts were considered candidates for elective

surgery only. Since most of these thin-walled cysts cannot be shelled out like a benign tumor, removal by either lobectomy or segmental resection is usually necessary.

Infected cysts were always treated by surgery. Before the sulfonamides and penicillin were available, large infected cysts were often treated primarily by drainage. When adequate drainage was obtained, excision of the cyst was necessary to effect healing. For the past two years at Walter Reed General Hospital infected cysts have been excised without preliminary drainage. Penicillin protection has probably been an important factor in the success with these cases.

TUMORS

It is not in the province of this report to describe in detail the many and various types of thoracic tumors found in Army personnel. Routine roentgen examination resulted in the discovery of many neoplasms. For example, 109 mediastinal tumors were discovered in five chest centers and successfully treated. There were many cases of bronchiogenic carcinoma despite

the young age group encountered. Results in this series were discouraging because in most instances the lesion was inoperable by the time the diagnosis was made and because there was a high incidence of highly malignant peripheral bronchiogenic carcinoma which gave no warning until metastasis precluded successful treatment. The results in patients of the older age groups in whom centrally located squamous cell carcinomas were found were far better than in young individuals.

CONCLUSION

Thoracic Surgical Centers were established for the first time in World War II. The advantages of the center system have proven themselves by increased professional efficiency in the care of sick and wounded patients. Secondary to therapeutic efficiency have been the opportunities of studying large, compact series of patients with chest diseases.

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SURGICAL MANAGEMENT OF WAR WOUNDS OF THE ABDOMEN

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THE management of abdominal wounds incurred in war has been the subject for constant review during each new war and for a relatively short period thereafter. The mortalities reported have gradually improved as methods of evacuation have been speeded up, and early mass surgery with adequate supportive treatment and blood replacement combined with newer methods of chemotherapy been made available in forward areas.

PRE-HOSPITAL MANAGEMENT

There is not room nor intention here to discuss the evacuation of the wounded but the various progressive treatment stations in order will be recalled: The first aid, the clearing station, and the Surgical Hospital or the Field Hospital augmented by Surgical Teams, and the Evacuation Hospitals (400 bed semi-mobile and 750 bed types) all in the forward or combat zone. It has been the policy of the United States Army in general to avoid major surgical operations in institutions forward of the Surgical or Field Hospitals surgically augmented. Isolated airborne or armored units at times have had to disregard this policy but the early and conclusively demonstrated fact that abdominally wounded will not stand transportation postoperatively before ten days or even two weeks has made it mandatory that they be transported preoperatively to such a point where adequate surgical preparation, treatment and postoperative care without interruption for transportation before their condition permits, may be achieved. The early deaths in the abdominally wounded are largely the result of shock, either alone or more

frequently associated with hemorrhage. Shock, the result of the initial trauma, will, if hemorrhage is not too grave a factor, usually respond enough to plasma infusion, conservation of body heat and alleviation of pain, to allow the patient, properly splinted if associated injuries indicate, to be transported to the adequately equipped mobile operating theatre. We thus see that those caring for the abdominally wounded, forward of the hospital institutions, can only dress their wounds, treat the patient's shock, give them morphine as needed, control external visible hemorrhage (by direct hemostasis) while trying to speed their evacuation. It has been clearly demonstrated that if hemorrhage has been of any degree, whole blood is needed and makes the best replacement, and during the latter phases of the war, this was available at the clearing stations, while plasma was available at the first aid stations. It is the author's personal belief that too often technical complications beyond the control of the administrator, as available transfusion needles being too small or filters too tightly packed or clogged, interfered with rapid administration of the plasma, the procedure thus requiring too long a time, thereby not giving the patient as prompt a boost as needed while allowing the passage of valuable time before he was evacuated to the hospital. Certainly, these difficulties constantly beset us in the forward hospitals. In the American Army, the immunization of all its members against tetanus early proved itself, and so during the time the patient was receiving his early supportive therapy, tetanus toxoid in a stimulating dose was always given. As the war progressed penicillin

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became available and early and prompt administration of the drug has seemed worth while, although when contamination of the abdominal cavity by penicillin resistant organisms has generally occurred (*Bacillus coli*) its therapeutic benefits have been limited. The early use of intravenous sulfonamide preparations would seem advisable and perhaps when the next war supervenes, all those in immediate danger will keep their intestinal bacterial flora to a minimum by pre-battle sulphathaladine or sulfasuxidine, or oral streptomycin.

Not infrequently a perforating missile will upon leaving the abdomen tear away a considerable portion of the abdominal wall and either carry with it or be followed by considerable lengths of small intestine. The author has seen repeated instances when under these circumstances the eviscerated bowel has been free of perforations. The question of early intra-abdominal replacement prior to reception at a hospital immediately presents itself. If the eviscerated intestine, though intact, shows signs of interference with its blood supply, this may be due to torsion or tension on the mesentery; and under these circumstances, especially if dust and dirt has not been ground into the intestinal wall due to clothing protection, careful replacement would seem indicated. Exposed loops which remain out may become gangrenous if forced delay in operation keeps them exteriorized for prolonged periods. Quite obviously, however, if the circulation of the bowel has been compromised as the result of direct trauma to its blood supply, nothing more than a protective external dressing is indicated. In general, if the loops are covered with soilage, gentle cleansing with preferably warm saline, the abdominal wound being protected, should be done, the loops then sprinkled with sulfanilamide crystals, and covered first with dressings moistened in saline (aid stations, or clearing stations at least) and finally heavy bulky dressings, the whole gently but firmly strapped in

place with adhesive. If the patient has had adequate shock treatment and is not bleeding, he can be transported quite well in this condition. Likewise, in general, if there is considerable loss of the abdominal parietes, adequate protective dressing should also be applied.

PREOPERATIVE MANAGEMENT

In the preoperative preparation of these patients, upon reception at the point where definite surgery is to be performed, thorough estimation of this patient's condition is essential. The great majority of the abdominally wounded will require at least one blood transfusion prior to surgery and those bleeding or who have lost considerable blood may need as much as 2,000 cc. or even at times almost double this amount. An early accurate estimation of the degree of shock, the amount of blood loss, and the presence of continued bleeding are of prime and foremost importance in the management of these patients. In war, associated injuries are the rule and bleeding from an extremity wound may be contributing appreciably to the patient's shock. Emergency control of the latter thus forms a definite part of the shock therapy. The more severely shocked patients were usually given oxygen through a B.L.B. mask as it seemed definitely to contribute to a favorable response. Patients in shock who are not bleeding will usually maintain their rise in blood pressure achieved as the result of their supportive treatment. In general, it has been the author's experience that blood and plasma in a ratio of about 1 to 1 or slightly greater, gave the best overall response. Plasma was begun immediately on all shocked patients upon admission because of its ready availability and blood, when cross-matched, then started in the other arm, if, as so often unfortunately was not the case, the other arm was not denied because of injury. Blood was routinely cross-matched although at times the severity of the emergency will make this omission man-

datory. Those patients in whom an initial favorable response to anti-shock therapy is not maintained are probably still bleeding and every effort should be made to get these patients to the operating room with all speed, whole blood replacement being kept going during transfer to the operating room and during anesthetisation and subsequent operative work. Patients who respond readily to this blood or plasma therapy, whose abdomens are tense, are probably suffering from a perforated viscus and early peritonitis. However, in these, if the missile has only penetrated and not perforated the abdomen, there is usually sufficient time to allow an x-ray of the abdomen to try to determine the location of the retained foreign body. This information is always helpful in deciding the best incisional approach. It has been the common experience of those managing the abdominally wounded that the additional time necessary properly to stabilize the patient's circulation is more important in reducing mortality than avoidance of a few extra hours of soilage by intestinal contents. This period often is three to four hours in length while actually under the mass flooding of the hospital by casualties during particularly heavy action, the unavoidable surgical backlog may force a longer preoperative period even up to eight hours at times, under unusual circumstances rarely more. In the author's personal experience in the management of 457 abdominally wounded, brought to the hospital for initial surgical treatment, thirty-eight died before operation could be performed. Some of these, obviously moribund, never responded to therapy; others made a temporary slight response but slipped back into irreversible shock before operation could be arranged or even while being transported to the operating room. A pressure over 100 mm. of mercury systolic was one of the aims of preparation along with a pulse below 120 if possible. The variations in the efficacy of treatment and promptness of

surgical operation will always vary with the varying duress of circumstances and the surgical backlog. The mortality some months was 10 per cent and almost all came to surgery; other months it reached 30 per cent, with appreciable mortality in the shock wards. The overall mortality in the 457 abdominally wounded primarily handled on the author's service was 21.2 per cent. The postoperative mortality on 379 operated upon was 15.3 per cent. These figures do not include fifty-five thoraco-abdominal cases reported elsewhere, nor forty-nine postoperative patients received at various times from field hospitals or clearing stations (armored) in front of us.

In war, many have eaten fairly recently prior to their wounding and an attempt to evacuate the stomach of its liquid contents should be promptly made. Larger undigested food particles will not be evacuated; but if air and liquid gastric contents are evacuated, anesthetic accidents will be avoided, and the patient's response to anti-shock therapy will be more prompt. This has been repeatedly seen when acute gastric dilatation was found in patients with severe extremity wounds without any abdominal penetration, the patient responding poorly until after the dilatation was relieved.

Before leaving discussion of the treatment of shock in these patients, a note of discretion is interjected with regard to indiscriminate fluid administration. For a while 20 per cent of our postmortem specimens showed hemoglobinuric nephrosis on microscopic section. As the war progressed across the European Continent, those wounded by fragments from enemy artillery more often showed associated blast injury effects and in a number of cases fatal pulmonary edema resulted, perhaps precipitated by too energetic fluid replacement though it might have occurred even on a régime of restricted fluids. If evident, as shown by pulmonary râles, hemoptysis or dyspnea, a patchy clouding on x-ray, extreme caution is needed in fluid adminis-

tration both pre- and postoperatively. All of these patients need oxygen, even at times under slight pressure though its efficacy has not been incontrovertibly proven. There were about six deaths from transfusion reactions during the year despite satisfactory cross-matching.

In the further preparation of these patients for surgery, x-ray examination of the abdomen for location of retained foreign bodies has been mentioned. When either a perforating wound or the portion of the retained foreign body indicated that the missile has crossed the pelvis, proctoscopy or sigmoidoscopy should be done to determine if any perforations of the rectosigmoid have occurred. The presence of fresh blood may be noted at times when the actual perforations are not visible. It has not been an uncommon finding at abdominal operation to find the wound tract extraperitoneal; but if the rectum has been perforated, colostomy must be performed. The knowledge of the perforations must of course be obtained prior to laparotomy. Similarly, all patients should have a urinalysis if there is any possibility of injury to the urinary bladder or kidneys.

ANESTHESIA

It has been the general experience that ether anesthesia has been the anesthesia of choice on these patients. If recently shocked, they tolerate spinal very poorly. If there is any chance of diaphragmatic involvement, intratracheal anesthesia is indicated. In reviewing the first 10,000 anesthetics of our hospital after landing in Normandy, it was found that 40 per cent of the ether anesthetics were intratracheal. The presence of a pulmonary blast injury contraindicates an ether anesthesia, as several times pulmonary edema has followed such an error when the presence of the blast effect was not previously recognized. Under such circumstances, and at times when pulmonary complications as atelectasis, or perhaps just general toxicity or extensive injury seem to contraindicate a general anesthetic, bilateral intercostal

block from T 6 to 12, supplemented with local infiltrations of the operative site, may be used and has proved satisfactory a number of times for our unit. At this point a word of caution is indicated concerning routine preoperative or preanesthetic medications. Very severe respiratory depression has been repeatedly experienced in severely shocked patients who have received several injections of morphine during evacuation, while at the same time not absorbing it due to their shocked condition. The supportive measures used in their preoperative treatment may bring them out of shock, thus improving their circulatory condition and producing a sudden absorption of the subcutaneously accumulated dose with the very distressing depressant respiratory effects, resulting in an anoxia which is definitely harmful to the patient. Immediate postoperative aspiration of the tracheobronchial tree, either through the intratracheal tube or by direct bronchoscopy seemed to reduce the incidence of postoperative atelectasis, which was much greater in incidence after laparotomies than after thoracotomies; the latter group were almost routinely bronchoscoped immediately postoperatively.

OPERATIVE MANAGEMENT

Incisions. In deciding upon the approach to be used the course of the missile, if known, will greatly influence the decision. A rectus or paramedian incision of adequate length over the side suspected of the major portion of damage will give adequate exposure. In injuries involving the spleen, splenic flexure of the colon and left renal area, as a perforating wound in the hypochondrium from front to back, a subcostal incision has often proven very adequate. Small diaphragmatic perforations may be repaired from this approach as well. However, when one is faced with a thoracoabdominal wound on the left in which the course of the missile as determined has been confined to the upper outer quadrant of the abdomen involving probably the spleen and diaphragm, transthoracic (ninth

rib) transdiaphragmatic approach (under intratracheal anesthesia) has allowed repair of the injured lung, splenectomy with ease when indicated, as well as repair of the splenic flexure of the large bowel and inspection of the stomach and upper small bowel. When the course of the missile has been from the chest into the abdomen, we more often performed our surgery through the abdominal approach. The reverse course of the missile was more likely to leave an open pneumothorax at the wound of exit and already caused considerable pleural contamination so that in this type the transthoracic approach was almost mandatory. In general, the operative incision should be through the site of election, and the missile wounds treated only as such, i.e., débrided, peritoneum and deep fascia closed, while superficial closure may be attempted in clean wounds or the placement of sutures for secondary closure in a few days may avoid deep troublesome infection.

MANAGEMENT OF SPECIFIC INJURY

Hemorrhage. When the abdomen is first opened, the presence of blood in any amount will require first the determination of the source of bleeding and its control. Patients often times will make a markedly favorable response to their shock therapy following control of the bleeding. The routine examination includes the spleen and liver and mesentery of the intestine, severed vessels in the latter often causing very marked losses of blood. Wounds of the stomach and upper small intestine are often times associated with severe hemorrhage. If examination of these possible sources fails to reveal the cause, hemorrhage from injuries to major retroperitoneal vessels must be considered. The author recalls several very striking examples of the latter. The first of these occurred in Southern Tunisia in a soldier with a penetrating wound of the back. In the early days of the campaign suction apparatus was not available except as ingenuity furnished and in this case the abdomen was

filled with blood. Removal by large sponges could not keep up with the flow, and rapid spleen, liver, gastric, and mesenteric examinations were negative. Exploration of the lesser omental cavity from which the bleeding seemed to stem revealed the source as behind the middle superior edge of the pancreas, apparently due to transection of the splenic vein. Another example revealed the source to be the right common iliac vein which was controlled by extraperitoneal ligature through a separate inguinal incision. Another time the persistent bleeding was coming from a hole in the posterior peritoneum from a major vascular injury of the renal pedicle necessitating nephrectomy. Thus, upon opening the abdomen, control of hemorrhage is the first consideration.

Spleen. Major wounds of the spleen require splenectomy. Occasionally, bleeding seems self-arrested and exploration shows a superficial crease of the spleen. We have repeatedly treated these conservatively if small and no longer bleeding and have known of no ill effects therefrom. This has been reported by Imes¹ as well.

Liver and Diaphragm. In the case of liver lacerations, if large, we have used a heavy catgut suture on an atraumatic needle for deep mattress sutures with packing of any areas of stellate injury or tissue loss, and always drained by penrose drain through a stab wound. While the author was making an official follow-up tour of general hospitals in England during the lull in the fighting in the Fall of 1944, he came across one case in which the drains in such a case had been removed at ten days and the patient developed a bile peritonitis four days later. Although unduly long retention of packing may produce secondary adhesive effects (it has produced secondary intestinal obstruction requiring operation) an adequate escape route should undoubtedly be maintained for drainage of bile for about two weeks.

Although properly belonging under discussion of thoraco-abdominal wounds, if

at abdominal exploration a wound of the diaphragm over the liver is found, it should be closed and subphrenic drainage instituted. The usual approach for this type of wound will be transpleurally with repair of the diaphragm and subphrenic drainage through a subcostal stab wound with closed intercostal catheter temporary pleural drainage. If this is not done, a thoraco biliary fistula will almost always result necessitating later open thoracotomy, repair of the diaphragm and subcostal subphrenic drainage. It is also quite evident that in any thoraco-abdominal wound approached through the abdomen, the diaphragm should be primarily closed after control of any hemorrhage. An open diaphragm subjects the patient to the same shocking disturbances of respiratory physiology that occurs in an open pneumothorax. The diaphragm should be routinely examined in exploration of wounds of the upper abdomen.

Before considering specifically the wounds of the gastrointestinal tract, a few more words of discussion about liver injuries is needed. In the author's unit, of 457 wounded with primary abdominal wounds brought to the hospital, forty did not receive laparotomy. The mortality in this group was 5 per cent, mainly embolic in origin. Over half of these cases were small penetrating wounds of the liver with missiles of 1 cm. or less in size having entered the liver substance through the posterior, lateral or high anterior approach, the position of the foreign body, if retained, being within the liver substance. The known tract of the missile precluded pleural or other abdominal visceral injury. In these cases, conservatism may be used under constant vigilance to recognize early biliary drainage into the abdominal cavity which will of course require laparotomy. The question of removal or retention of foreign bodies will be discussed separately later.

Pancreas. Wounds of the pancreas have occurred in only moderate frequency, and repair of the capsule and establishment

of external drainage has adequately taken care of them. Pancreatic fistulas were distinctly unusual, and digestion of the skin about the external wound has often failed to occur or been very minimal.

Stomach. Wounds of the upper gastrointestinal tract are often associated with considerable hemorrhage, especially gastric wounds. If one finds an intestinal perforation, he must seek a second one, as the foreign body with rare exception passes through the hollow viscus and, therefore, there must be both a wound of entrance and exit. In examining the abdomen, after incision and control of hemorrhage, a routine of exploration should be adopted. In our unit, this has generally been first the small and then the large bowel. If a large rent is evident to decrease spillage on Allis clamp or two is immediately used to approximate the defect and reduce the spillage; especially in large intestinal lesions has this seemed particularly indicated. In perforating wounds of the stomach, one wound is frequently posterior and opening of the gastrocolic omentum will more often be necessary to discover and repair the posterior wound. In closing gastric wounds, if two ragged holes present in close proximity, the quickest repair will be accomplished by uniting these into one large simple opening and then closing it transversely to the axis of the stomach. A running suture of chronic catgut through all layers followed by an inverting seromuscular (Cushing or Lembert) suture of atraumatic catgut or No. 3 silk has been used, a few interrupted reinforcing sutures of silk finally being placed. A Connel type of suture has also been quite satisfactory at times and insures inversion of the suture line. Interrupted sutures have not been used generally as multiple wounds are the rule in these patients and time for repair must definitely be gauged and conserved.

Duodenum. Wounds of the duodenum have fortunately not been too common, but have a high incidence of complications, especially breakdown of the repair,

localized abscess, generalized peritonitis or duodenal fistula. If the duodenum is open, the result of injury, the position of the ampulla with relation to the intestinal wound should be determined. If any of the retroperitoneal portion of the duodenum has been involved, the incidence of complications, repeatedly fatal, has always been high. It is probably a safer procedure, if loss of duodenal substance is extensive or technical difficulties are otherwise too great, to complete a satisfactory anastomosis to close the open duodenal ends separately and perform a gastro-enterostomy, with prophylactic penrose drains down to the area where any possible duodeno-biliary leakage that may occur. Drains must, of course, be kept away from the immediate location of suture lines. By incision of the lateral peritoneum where the duodenum becomes retroperitoneal, more adequate exposure may allow repair. A drain posteriorly or laterally if the retroperitoneal area has been involved in the wounding would seem advisable. Small duodenal wounds may be satisfactorily closed by purse-string suture, reinforced by a second row of interrupted sutures.

Jejunum and Ileum. In wounds of the jejunum, due to the relatively larger size of this portion of the intestine as compared to the ileum, one can generally perform the obvious type of repair without fear of secondary obstruction. If several perforations are located in close proximity to each other, it is simpler and quicker to join them by cutting, converting the wounds into a single one which may then be closed by a simple line of suture (usually two layers) with its line transverse to the direction of the bowel. In the author's unit, a double row of running chromic catgut with the inner through all coats and the second only seromuscular, proved routinely satisfactory. Occasionally, the second row was made with silk when atraumatic catgut sutures were not available. Not infrequently numerous multiple perforations may occur within one small

segment of the bowel. Under these circumstances, resections of the involved area may save considerable time and avoid constriction of the lumen that might follow attempt to suture individually all the perforations if quite a few are all located within a very small segment. Traumatic transections of the bowel may be repaired by an end-to-end anastomosis in the jejunum. In the ileum, due to the smaller lumen, closure of the ends and side-to-side anastomosis has proved more feasible. When the ileal transection is incomplete, the mesenteric portion has often been uninjured and an end-to-end anastomosis has proved feasible. In our experience,² multiple intestinal injuries have occurred ten times as frequently as single perforations. Despite routine examination of the entire small bowel by all operating personnel, small intestinal perforations were missed three times, twice in abdominal explorations and once in a transthoracic exploration of a thoraco-abdominal wound. As exceptions to the rule, two of these came to postmortem at a later date and proved to be tiny lacerated wounds.

Colon. In handling wounds of the large bowel, the principles of management differ somewhat. Frequently in patients very severely injured and in whom a minimum operative procedure is indicated a simple exteriorization as a loop colostomy of the wounded portion will be all that can be done. When colon wounds are primarily closed and dropped back, a high incidence of secondary suppurative intra-abdominal complications has occurred, along with secondary breakdown of the suture line. When the perforation is so located that exteriorization would greatly increase the operative work, as extensive mobilization in the case of flexure wounds, or otherwise as in low sigmoid wounds in which exteriorization is not feasible, a proximal decompressive procedure as a transverse colostomy or cecostomy has been used. Wounds of the cecum or low ascending colon can be exteriorized as a cecostomy.

If soilage of the abdominal cavity has been considerable about the colon wound, a penrose drain through a stab wound from the usual sites of collection seems to lessen the incidence of postoperative abscess. In the case of splenic flexure wounds when splenectomy has been necessary, the incidence of secondary subphrenic abscess has seemed notable. This has occurred at least three times in the author's unit, each time fortunately responding to drainage. The type of colostomy to be performed either for decompressive purposes or for exteriorizing the wounded segment has had a varied vogue. In the fall of 1944, the spur type was requested by the general hospitals in England. However, retraction of the loops, secondary interpositions of small intestine and frequent inability to mobilize enough bowel when exteriorizing wounded segments near the flexures led to so many secondary difficulties in closing these wounds in the general hospitals that early in 1945, a request was made for simple loop colostomy with the usual longitudinal incision of the anti-mesenteric surface for opening. It was found that subsequently in the general hospitals, these could be closed and dropped back into the abdomen with a very low incidence of infectious complication, the previous heavy vaccination of the peritoneum at the time of original injury having developed an appreciable degree of immunity.

In the case of small single perforations of the large bowel, the author has a number of times closed them but exteriorized the affected portion as a simple loop. After three days the supporting rubber tube used beneath the loop was removed if the suture line appeared to be healing, thus dropping the loop back somewhat into the wound. These repairs were successful in selected cases in about 90 per cent of the cases and allowed the healed loop to be dropped back into the abdomen in about two weeks, thereby shortening the patient's hospitalization considerably.

Rectum. One finally comes to the last portion of the intestinal tract, the extra-

peritoneal rectum. Wounds traversing the pelvic girdle may perforate the rectum and be extraperitoneal. Proctoscopy is mandatory in any suspected wound of this type if its presence is not definitely known. When it occurs a sigmoid colostomy of the spur type isolating the distal bowel segment is indicated. The rectal wound should be drained by thorough débridement of the wound tract, and in addition drainage of the infraperitoneal and pararectal spaces by posterior midline incision down to the coccyx and through the fascia propria. When external drainage of these perirectal infected spaces is not instituted, nor colostomy performed proximally, spreading infection, abscesses and sinuses result. Hugh necrosis and infection of the gluteal muscles may follow, if the wound tract leads through this area. Coccygectomy and repair by suture of the perforations has been frequently advocated. Osteomyelitis of the sacrum³ (Colcoth) has followed coccygectomy; and when the perforations of the rectum have been tiny, they have frequently healed without fistulas or complication if the fecal stream has been completely diverted and the infraperitoneal space simply drained⁴ (Croce, Johnson, and Wiper).

The closure of colostomies in general has followed standard technics of preparation and closure when the original colostomy has been free of complications. Many times in the ETO, however, the author found during a tour of general hospitals, the tight retracted colostomy loops have necessitated a formal intra-abdominal approach and anastomosis which, as mentioned earlier, was found to be surprisingly successful. In the initial operative creation of the colostomy, they should be kept away from the exploratory incision and if possible from any compound fractures, as especially the ilium, as in the former case, wound infection and dehiscence and eviscerations have not been infrequent, and in the latter, osteomyelitis has been a distressing complication.

Gallbladder. Wounds of the gallbladder have not been mentioned. These occurred

only about a half dozen times in the series observed, and simple closure if possible and drainage of the surrounding fossa has proved adequate several times. If extensive damage, cholecystostomy or cholecystectomy may be required, depending on the degree of damage. All wounds of the biliary and urinary tract were drained.

Urinary Tract Wounds. Before abdominal exploration, a urine specimen should be checked for hematuria. If present, it usually originates in either a wound of the kidney or the bladder, as wounds of the ureters have proved a rarity below the pelvis of the kidney. The author can recall only one in the series followed. If the bladder has been involved, the perforation may or may not involve the peritoneum. If the peritoneum has not been involved an extensive edema of the posterior and inferior pelvic reflection over the bladder may be evident. In these cases, the bladder has been opened through an adequate incision and the space of Retzius freed up by blunt dissection, the latter being carried well down toward the base in low lateral wounds. An attempt to close the bladder perforation by a mucosal suture layer and a second muscular suture, has always been made. Following this the bladder is closed about a cystostomy tube. This should be brought out as high as possible from the bladder dome, that is cephalad, as cystostomy tubes brought out immediately over the symphysis pubis have frequently resulted in secondary erosion and infection of the latter. Some perineal wounds may pass just beneath the bladder and sever the posterior urethra. We have used a mushroom catheter, preferably a Foley bag, which was threaded on to a urethral sound first guided up into the bladder in retrograde fashion by palpation with the finger in the bladder urethral orifice, the catheter serving as a splint for the urethra. Adequate débridement of the external bullet wound, usually near the perineum may serve for external drainage; but if there is any evidence of

urinary extravasation, adequate perineal drainage should be instituted. In the author's unit, one patient explored for a perforating wound was found to have multiple small intestinal perforations which were repaired. The wound of entrance had been low in the abdomen and at surgery was noted to be near the dome of the bladder. Catheterized urine was negative and the bladder was not explored. Three nights later during a heavy rush period the patient developed markedly increased abdominal distention and after being unable to void was catheterized. Over 2,500 cc. of blood tinged urine was obtained and the abdominal distention seemed lessened. However, the patient continued a downhill course and at post-mortem it was found the bullet tract had severed the muscle of the bladder but not penetrated the mucosa. Apparently this ruptured later spontaneously into the abdomen with the unfortunate results that ensued.

Ureteral injuries have been notable for their comparative rarity. If location and type of injury prevents reimplantation into the bladder or attempt at repair over a ureteral catheter with external drainage, an external ureterostomy (cutaneous) should be done as a temporary measure for reconsideration later as to further reconstructive surgery.

Wounds of the kidneys were generally treated quite conservatively. If examination of the wound suggested a perforation by a tiny missile and physical examination showed no evidence or signs of retroperitoneal irritation, débridement of the wound was all that was done. If the wound was appropriately situated, a penrose drain was frequently inserted. However, if the size of the missile and its known course indicated the possibility of major renal damage, the kidney was explored. Fragmented kidneys were removed as well as those with the pelvis of the kidney shot away. The author recalls a case of multiple intestinal wounds resulting from land mine fragments in which exploration of a posterior abdominal perforation through which

large amounts of blood were flowing into the abdominal cavity revealed the source as the renal pedicle. Ligation of the pedicle was necessary for control so the kidney was removed through the anterior wound, the posterior peritoneum closed and the retroperitoneal space drained posteriorly. This worked very well. If the kidney is removed through the peritoneal cavity, we have always used a retroperitoneal drain and closure of the posterior peritoneum. We have removed the kidney several times transpleurally (transdiaphragmatically) when injured severely along with the spleen, diaphragm and lung. Subcostal incision has worked well as has the classical posterolateral incision. However, many times the associated intraperitoneal injuries make a separate or posterolateral approach impractical for handling all the wounds encountered.

POSTOPERATIVE MANAGEMENT

All patients with major intraperitoneal wounds were placed postoperatively on a régime of gastric suction, vigilant fluid balance to maintain a minimum daily urinary output of over 1,000 cc., with total intake to 3,000 cc., using 5 per cent glucose and normal saline while the gastric suction remained in place, otherwise only 1,000 cc. of normal saline and the remainder 5 per cent glucose. At least 500 cc. of blood plasma was given daily to try to replace in part the metabolic protein loss of the patient receiving nothing by mouth; thereby retarding the development of hypoproteinemia and aiding wound healing. Vitamin B₁ and vitamin C in doses of 10 mg. and 100 mg., respectively, daily were given intravenously. In the entire series there was only one wound disruption, and ileus was relatively rare. Sulfonamides were used routinely beginning with an early intravenous dosage of 5 Gm. of sodium sulfathiazole or sodium sulfadiazine and then 2.5 Gm. every eight to twelve hours as necessary to maintain an adequate concentration, while daily urinalyses and bi-daily blood counts were closely scruti-

nized for evidence of urinary precipitation of the drug (red cells or crystals) or depression of the hematopoietic system, either of which called for discontinuance of the drug. After a year in the Mediterranean Theatre, the unit entered France D + 4 in Normandy and penicillin was available for the first time. This was given in doses of 40,000 units every four hours though it is now accepted as being more efficacious if given at three-hour intervals. Although the latter drug aided wounds in general, it was difficult to say it changed our results as the postoperative mortality for the abdominally wounded in our hospital in the Mediterranean Theatre was less than that in the European. There are other factors, however, as heavier casualty reception, that can explain the difference.

Patients returning from a vigorous operative procedure were generally given oxygen by B.L.B. mask for twenty-four hours. This seemed of definite benefit. It was interesting to note that in our postmortem tissue sections as reported by the Army's Laboratory service, at times as high as 60 per cent showed microscopic if not gross evidence of blast injury in the lungs. The author has also seen repeatedly the postmortem finding of multiple epicardial and myocardial petechiae and ecchymoses in the heart where the known tract of the injuring missile has been over six or eight inches away. Transpelvic wounds where bony structures have been fractured have several times seemed associated with enough lateral transmission of the blast effect of the missile itself to produce these effects. Several times these findings have been limited to the diaphragmatic surface of the heart and the neighboring diaphragm. A word of caution should, therefore, be injected about the injudicious excessive use of fluids postoperatively if there has been any moisture in the lungs, hemoptysis or cyanosis. Ether anesthesia increases the pulmonary edema associated with the blast injury and the occurrence of a number of deaths from pulmonary edema several days postoperatively in patients who had not received over 2,500

cc. of fluids intravenously daily was a very disheartening complication.

Patients were started on a liquid, low residue diet with the return of normal peristalsis, the disappearance of distention and the passage of flatus.

EARLY COMPLICATIONS

Shock has been discussed. Postoperatively it still accounted for a very considerable number of deaths in the first twenty-four hours. Its treatment has been discussed. Blood was used liberally, precautions being taken to detect blast injury effects. The use of serum albumin seemed to be of definite though limited value.

Pulmonary edema has already been mentioned. Concentrated serum albumin in 100 cc. vials was available during the last two years of the war and this proved a very definite adjunct to the treatment of pulmonary edema in the early stages but was ineffective in the more marked cases. Positive pressure of oxygen seemed to accomplish no more than oxygen by the B.L.B. mask.

Pulmonary embolus accounted for a considerable share of the deaths. In the author's unit one soldier at postmortem had massive clots and thrombi filling the main pulmonary vessels. The source was found to be venous thrombosis about a retained foreign body in the flank about which some abscess formation had occurred. Prophylaxis against this complication was attempted by deep breathing exercises, frequent turning of the patient in bed and encouragement to move his extremities. Anticoagulants were not available, nor heat cradles for the lower extremities, as a mobile hospital unit must conserve in equipment and expenditure of electricity which it has to manufacture itself.

Pulmonary complications, especially atelectasis, was relatively common postoperatively during the colder months. The incidence was higher in the abdominally wounded than in our thoracic cases, many of the latter being routinely bronchoscoped

at the close of the operative procedure. Had this been done with the abdominally wounded, the morbidity of this complication might have been lower.

Peritonitis and secondary abdominal abscesses must be watched for. Under our present day chemotherapy the signs and symptoms are very often masked. We had one patient with a closed abdominal injury with a five-day ruptured sigmoid colon, come in with a soft abdomen only to go on to distention and death from generalized peritonitis. Abscesses were most commonly found in the pelvis, subphrenically on the left, subhepatically on the right and in the epigastrium in the vicinity of the upper greater omentum, on in the lateral "gutters." Several patients developed pelvic abscesses while in our institution. All but one were drained surgically, the other evacuating spontaneously into the rectum. The pelvic abscesses were more often drained under local anesthesia. Subphrenic abscess on the left several times followed splenic flexure injuries in which splenectomy had also been necessary. Drainage in all resulted in early recovery.

Small intestinal obstruction occurred in the early postoperative period about a dozen times. Three required surgical intervention while the remainder responded to introduction of the Miller-Abbott tube. This was passed under fluoroscopic control, the passage through the pylorus frequently requiring repeated observation at twenty to thirty minute intervals. Two cc. of mercury in the inflatable balloon considerably shortened the procedure.

LATE COMPLICATIONS

Transportation under ten days postoperatively was fraught with danger and evisceration not uncommon in the early days of the war. A routine theatre order later required through-and-through stay sutures, and this greatly reduced the incidence of this distressing complication. Wounded, suffering from mild respiratory infections when hit have an increased incidence of pulmonary complications attended with the inevitable cough. If

they became hypoprotinemic or are suffering from relative vitamin deficiency, evisceration may be more often anticipated.

Amongst late complications as seen in the general hospitals (during tour of hospitals in England) was some form of sequellae to improper colostomies. This has been referred to earlier. When the loops of the colostomy were under tension, inflammatory reaction about them not infrequently caused the loops to retract below the surface of the abdominal wall with abscesses of the abdominal wall and fistulas. Gangrene of a colostomy loop may also occur if tension is sufficient to interfere with its blood supply. When colostomies were brought out the abdominal exploratory wounds, and secondary infection occurred, as it more often did, small bowel fistulas were not an uncommon additional complication, in addition to breakdown of the wound itself the result of unavoidable gross infection.

Pleural complications following liver or left-sided kidney wounds usually result from a transdiaphragmatic wound of the respective organ where, the diaphragm may or may not have been repaired but no external subphrenic drainage was instituted. Transpleural repair of the diaphragm after first placing a subphrenic subcostal drain through a stab wound from within out (while the diaphragm is open) with closed intercostal pleural drainage seems the only way to avert a chronic pleurobiliary fistula and chronic empyema.

The question of the removal of retained foreign bodies is always perplexing. One example was given of the fatal complications following retention of a sizable one with subsequent abscess formation. In many instances they cause no further trouble but larger ones can usually be located by careful search if within the abdomen. Retained foreign bodies in the liver are more often quiescent but occasionally produce an abscess which eventually ruptures into the subphrenic space. Prophylactically, if a large foreign body is thus known to be retained, the leaving

of the drain in place a little longer might avoid a subphrenic abscess. One case of bile peritonitis was reported in England fourteen days after wounding and four days after removal of a drain following injury to the liver.

Secondary intestinal obstruction has also occurred as a late complication. One general hospital reported an incidence just under 25 per cent with half of these requiring secondary operation. This figure, however, was greatly above the general incidence of this complication.

SUMMARY

An attempt has been made to relate the lessons learned in the management of over 500 war wounds of the abdomen treated on the author's service in an evacuation hospital overseas. Opportunity to follow up a varying number of these cases and similar one's was afforded at the close of several of the campaigns and included an officially sponsored follow-up tour of general hospitals in the ETO treating these cases in the later phases of their care. Complications which may occur have been mentioned. The late care of colostomies has been only mentioned as their care and closure when properly constructed initially follows standard surgical procedures. The importance of early supportive treatment, especially transfusion with whole blood has been stressed and the need for stabilization of the circulatory system, especially if continued hemorrhage has been excluded before undertaking surgery has been emphasized, being even more important than the time preoperatively. The value of intratracheal anesthesia has been discussed. Finally the complications to be looked for have been recounted.

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PERFORATING WOUNDS OF THE COLON AND RECTUM*

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IN the opinion of the majority of surgeons responsible for the primary surgery on the more severe types of battle injuries in the Mediterranean Theater during World War II, perforating wounds of the abdomen made greater demands on the skill and experience of the operating surgeon than wounds of any other part of the body. This was true even of those surgeons whose training had been largely in abdominal surgery and who might have been expected to have more difficulty with perforating wounds of the chest, head or extremities, all of which, of course, they were called upon to treat whenever the flow of casualties was heavy. Of the various viscera which might be injured in wounds of the abdomen, none presented more serious problems from the standpoint of mortality, morbidity and the exercise of correct surgical judgment than perforating wounds of the colon and rectum.

With this in mind it might be of interest to review an experience with 120 patients admitted to the wards of a general hospital in the Mediterranean Theater with perforating wounds of the colon or rectum. They have been divided into two groups: The first twenty-five were admitted during the winter of 1943 to 1944 and represented casualties occurring early in the Italian campaign. The second group of ninety-five cases was admitted between October 9, 1944, and January 15, 1945, after having been operated upon by forward surgeons, most of whom had then had one and a half to two years experience operating in the advanced field and evacuation hospitals.

GENERAL PRINCIPLES

The primary objective in the treatment of perforating wounds of the colon just as

in the treatment of battle wounds of any other type is the preservation of the patient's life. To accomplish this in as high a percentage of patients as possible, three fundamental principles must be kept in mind: First, the perforation must be dealt with in such a manner that a further leakage of intestinal contents into the peritoneal cavity is prevented; second, the manner of closure must be such that there is no marked impairment of the bowel lumen, and last, the procedure should be one that will add a minimum of shock to a patient already suffering from exposure, loss of blood and the trauma of a severe wound. The colon wound is usually associated with multiple wounds of the small bowel and other abdominal viscera and often with wounds of the extremities, perineum, buttocks and other parts of the body.

That marked progress toward this primary objective has been achieved is shown by a comparison of the mortality figures of patients with perforating wounds of the abdomen operated upon during this recent conflict with the mortality figures for similar groups of patients operated on during World War I. Then the mortality rate ranged from 50 to 75 per cent. In this war it has dropped to the neighborhood of 30 per cent. This includes those dying in the general hospital sometimes weeks after their injury, and is a tribute to the Medical Corps of the Armed Forces of the United States. It is the result partly of the early and adequate replacement of blood loss. It is frequently necessary to give blood to those patients in amounts as high as 3,000 to 4,000 cc. during the first twelve hours. It is also partly the result of the extensive use of the sulfonamide drugs

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and penicillin, both intraperitoneally and parenterally. More than either of these factors, it is due, I think, to the high degree of technical skill employed by the surgeons operating in our forward hospitals. In my opinion, the development of the highly trained surgical team consisting of surgeon, assistant, anesthetist and surgical nurse, often augmented by a medical officer trained in the treatment of shock, is one of the most significant advances made in the field of military surgery during this war. The widespread use of such teams in the field and evacuation hospitals, operating usually within a few miles of the front lines, has saved many battle casualties which a few years ago would have been considered hopeless from the standpoint of military surgery.

As the mortality decreased, it became possible to concentrate on a secondary objective, namely, to decrease the high morbidity associated with these wounds. All too often, separation of the laparotomy incision, retraction of the colostomy and the formation of intraperitoneal and subphrenic abscesses followed the successful primary treatment of the wound. Frequently, these complications were sufficiently serious to jeopardize the life of the patient.

Exteriorization of the injured segment of the colon has become an accepted principle in the treatment of the majority of perforating wounds of the large bowel, yet in 28 per cent of the first group of twenty-five cases the colostomy stoma was at the level of the skin or beneath when the patients were admitted to the general hospital. In 25 per cent of this group abscesses of the abdominal wall, adjacent peritoneal cavity or subphrenic space occurred. One patient whose original operative note mentioned that the segment of colon had been exteriorized with some difficulty, was admitted with a markedly retracted colostomy, pouring feces into a widely separated wound and the adjacent peritoneal cavity. The following series of major complications developed: extensive abdominal

wall abscess, left pericolic abscess, right pericolic abscess, large right pleural effusion, right subphrenic abscess, massive left pleural effusion, left subphrenic abscess, and finally empyema of the left pleural cavity. He represented a serious diagnostic and therapeutic problem for weeks and nearly succumbed on several occasions. He did not make a sustained improvement until the last abscess had been drained, in spite of extensive chemotherapy, penicillin and supportive treatment.

It is obvious that the bowel must not only be exteriorized but it must be exteriorized without tension. If there is any tension on the exteriorized segment, it will inevitably retract regardless of the type of support which is used to hold it above the skin. Exteriorization without tension as well as the formation of a spur of adequate length, if such a spur is desired, is dependent on adequate initial mobilization of the bowel. By incising the line of fusion between the visceral and parietal peritoneum, and mobilization of the mesentery of the bowel to its central attachments on the posterior abdominal wall, it is possible to exteriorize any segment of the colon, terminal ileum or sigmoid at some point on the abdominal wall without tension. Since all of this dissection is in a relatively avascular area, it can usually be carried out within a few minutes. (Fig. 1.) In mobilization of the right colon, the right ureter and the retroperitoneal portion of the duodenum must be identified, reflected posteriorly and preserved. On the left side care must be taken to reflect the left ureter as the dissection is carried medialward; and if the splenic flexure is to be liberated, the jejunum at the ligament of Treitz should be identified and preserved. Upon the completeness of this initial step a great deal of the success of the entire surgical procedure depends.

As experience increased and the problems of the forward surgeons were correlated with those of the men caring for these patients in the general hospital to which they were evacuated, a decrease in mor-

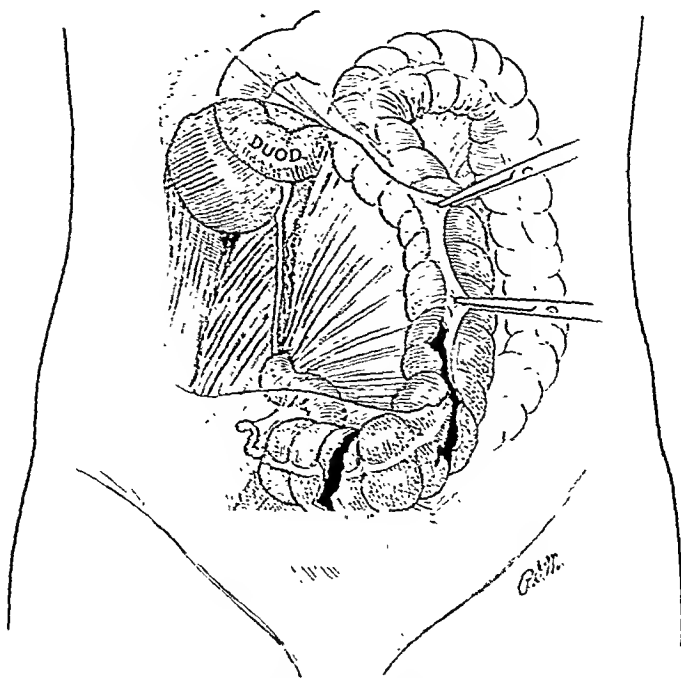


FIG. 1. Mobilization of the terminal ileum and ascending colon. As the dissection is carried medialward the right spermatic artery and vein come first into view. The right ureter will be found just medial to these vessels. At the upper end of the field the retroperitoneal portion of the duodenum will be exposed and must be carefully reflected posteriorly.

bidity occurred comparable to that in mortality. In this last group of ninety-five cases only 11 per cent had retraction of their colostomy to the level of the skin or beneath and only two of these patients had associated abscesses, one of the abdominal cavity and one of the right subphrenic space.

Double barrel colostomies with loops crossed in the form of an "x" and other irregularities which were occasionally seen in 1943 were not found in this last group of patients. No patient in this group was evacuated to the United States with his colostomy not closed because of technical difficulties arising from errors in its construction. In order to decrease as far as possible the high incidence of laparotomy wound suppuration and separation in these cases, the colostomy was routinely brought out through a separate lateral, muscle-splitting incision. In spite of this and other measures, in 10 per cent of this last group of cases there was separation of the wound down to the peritoneal level, and in three per cent it was complete, exposing the peritoneal cavity. However, in five of these

ten patients, including all of the complete separations, the separation was due to a strangulating type of figure-of-eight retention suture which produced slough of the entire fascial suture line in each case.

The essential objectives and fundamental principles of surgery of the colon following battle injuries are the same as those underlying surgery of the colon in peace time. The method of carrying out these principles and obtaining these objectives may necessarily vary considerably. It will vary with the type of injury concerned and may properly within limits vary with the individual surgeon.

WOUNDS OF THE CECUM AND ILEOCECAL VALVE

There were nine cases of this type in the last series of patients. If the wound is small and involves the anterior or lateral wall of the cecum, mobilization of the cecum and exteriorizing the injured area offers a simple way of treating the perforation. If the perforation itself can be exteriorized it will not only avoid the possibility of intraperi-

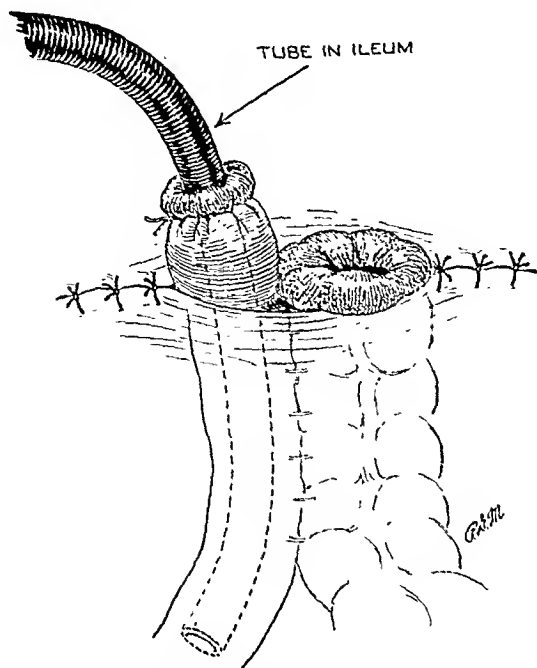


FIG. 2. The lacerated right colon has been removed and a double barreled ileocolostomy formed. After the dressings have been applied to the wound a large rubber tube is placed in the terminal ileum for immediate decompression, and soiling of the dressings and wound prevented by a tight ligature around the staggered, devitalized terminal ileum and tube.

toneal leakage, but a cecostomy of this type is definitely superior to the average tube cecostomy from the point of view of function. A well functioning cecostomy is particularly desirable if one elects to close by suture a perforation in the region of the ileocecal valve or in an area of the cecum not easily exteriorized. If a perforation of this latter type can be securely closed without impairment of the lumen of the terminal ileum, it is frequently possible to avoid a major surgical procedure by closing the perforation and providing a safety valve with the establishment of an adequate cecostomy at the point of election in the anterior lateral wall of the cecum.

It is with extensive injuries of the terminal ileum, cecum and lower ascending colon in which repair cannot be accomplished without undue risk of either leakage or obstruction or both or in which the destruction is so extensive that resection is the only feasible course that a difference

of opinion has arisen. I believe that the procedure of choice is mobilization of the right colon and terminal ileum, exteriorization and resection of the injured segment and the construction of a double barrel ileocolostomy spur consisting of the proximal uninjured ascending or transverse colon and the terminal ileum. (Fig. 2.) It is considerably less time-consuming and less shocking to the patient than exteriorization or resection of the injured segment, and side-to-side or end-to-end anastomosis of the ileum and transverse colon. This may be of vital importance if one is dealing with multiple injuries as is so often true in these cases. It also eliminates two hazards which must always be present when this latter procedure is carried out, namely, leakage or obstruction at the site of the anastomosis. The double barrel spur can be clamped on the seventh or eighth day following the operation, with prompt diminution in the amount of liquid discharge from the ileum and a rapid improvement in the appearance of the surrounding skin and of the patient.

The possibility of a high incidence of sepsis and separation of the colostomy incision because of the presence of the open ileum with its irritating liquid content has been raised as an objection to this procedure. This did not occur in the six patients who came under my care nor has it occurred in a rather considerable experience with an almost identical procedure used in the treatment of carcinoma of the cecum in peace time. The laparotomy wound should, of course, be protected against contamination by bringing the ileocolostomy out through a lateral, muscle-splitting incision. This has become an accepted principle of war surgery whenever a segment of bowel is exteriorized. If desired, a large rubber tube can be placed in the terminal ileum, held in place by a ligature or purse-string suture, and connected to a bottle at the side of the bed. This will usually function satisfactorily for four to five days, with little or no soiling of the colostomy dressing. (Fig. 2.)

No complications have been observed as a result of the application of a crushing clamp to the ileocolostomy spur as early as the seventh or eighth day following operation, and each of these six patients was evacuated with his ileocolostomy closed, bowels functioning normally and with no weakness at the site of the closure.

The only alternative to this procedure which has been recommended for severe wounds of the cecum and terminal ileum, apart from the seldom feasible primary anastomosis between the ileum and transverse colon with resection or exteriorization of the injured segment, is the establishment of a terminal ileostomy in the right lower quadrant and exteriorization of the proximal end of the colon below the costal margin following resection of the injured segment. Intestinal continuity is later restored by disconnecting the ileostomy, performing an anastomosis between the ileum and transverse colon, and then closing the colostomy. In my opinion, there are a number of objections to this procedure. In the first place, construction of a satisfactory terminal ileostomy is considerably more difficult than the construction of a satisfactory colostomy. A terminal ileostomy is difficult to fix securely to the abdominal wall so that retraction or prolapse will not occur. If either of these complications do occur, it necessitates an emergency surgical procedure in a patient who is in no condition to stand one. If the ileostomy does continue to function satisfactorily and the patient can be evacuated to a general hospital, he still remains a serious problem from a medical point of view. It is not advisable to subject these patients to the hazards associated with the evacuation of an ileostomy patient to the Zone of the Interior, and they require very careful observation even on the wards of a general hospital. They present a problem from the point of view of everyday nursing care because of the constant discharge of liquid or semiliquid ileal contents. The difficulty of maintaining adequate nutrition in patients with an ileostomy is well known,

yet in these patients their nutrition not only must be maintained but it must be improved to the point where they will withstand another major surgical procedure to restore intestinal continuity.

In certain instances, in spite of the desirability of closing their ileostomy at the earliest possible moment, complications or associated injuries may make delay imperative. Lastly, the elimination of the ileostomy and the anastomosis of the ileum to the transverse colon, when it is carried out, may have to be performed in the presence of adverse intra-abdominal conditions which could increase considerably the risk inherent in this procedure. These patients have all had varying degrees of generalized peritonitis. Adhesions will not only be present but we have observed at postmortem actual collections of liquid pus in various recesses of the peritoneal cavity and between loops of small bowel as long as five or six weeks following their injury.

WOUNDS OF THE COLON FROM THE CECUM TO THE RECTOSIGMOID

The treatment of wounds of the upper ascending colon, hepatic flexure, transverse colon, splenic flexure, descending colon and sigmoid will depend largely on the extent and position of the perforation. If the perforation is relatively small, that is 1 to 3 cm. in size, and involves the antimesenteric aspects of the bowel wall, exteriorization of the injured segment as a loop colostomy offers a safe and quick method of treatment. As a rule, it presents no unusual difficulties with subsequent restoration of intestinal continuity, even though at the time of closure it is usually necessary to expose a considerable portion of the adjacent peritoneal cavity in order to reduce satisfactorily the exteriorized segment; and the possibility of some degree of peritonitis, should there be any leakage of the suture line, does exist. I believe that, in the future, the principle of exteriorization will be modified for wounds of this type and that most of these small and moderate sized wounds of the antimesenteric surface

of the bowel will be closed by suture and the bowel replaced in the peritoneal cavity at the primary operation. If the wound involves one-half or more of the circumference of the bowel or if it involves the mesenteric border, a somewhat different situation exists. Here the exteriorization principle is undoubtedly safer and if the wound involves the mesenteric border, it necessitates complete division of the bowel to obtain an adequately functioning colostomy. Here we have two segments of bowel almost or completely separated, one from the other. Exteriorization, with approximation of the two loops of bowel by one or two rows of sutures so as to form a double barrel Mikulicz spur, permits the subsequent restoration of intestinal continuity by means of a relatively minor extraperitoneal procedure. This type of closure can be carried out by any surgeon in the base hospital with no risk of peritonitis. (In most of the cases in this series closure was made under procaine field block anesthesia supplemented by a small amount of pentothal sodium intravenously.) If a spur is not constructed for one reason or another, intestinal continuity in these cases will have to be restored by end-to-end anastomosis or by closure which will come very close to involving the entire circumference of the bowel. This is a procedure which even in the hands of experienced colon surgeons will probably continue to carry an appreciable mortality and morbidity.

It is of interest to note that in two patients with severe injury to the bowel, impairment of the blood supply led to a secondary slough of the exteriorized segment. In each case one loop sloughed to the peritoneal level and the other beneath the skin surface. The two loops, however, had been approximated so that following the clamping of the remaining spur, extraperitoneal closure of the colostomy in each case was accomplished without difficulty, leaving ample lumen at the point of closure.

It should be emphasized again that re-

gardless of what type of colostomy the operator elects to do, the bowel should be sufficiently mobilized so that it can be brought out well above the surface of the abdominal wall without tension. If a glass rod or rubber tube is being used to support a loop colostomy, for instance, the bowel should merely rest upon the rod or tube. If there is any downward pull, the colostomy will inevitably retract and the morbidity, if not the mortality, will be definitely increased. Among the eighty-four patients in this second group who were ambulatory and who had had their colostomies closed when evacuated to the United States, the only instance in which there was any fecal leakage from the colostomy wound following closure occurred in two patients whose loop colostomies had retracted. In one patient with an hepatic flexure loop colostomy, the stoma itself extended from the level of the skin through the abdominal wall down to the upper border of the liver. It had retracted and closure was made difficult because the hepatic flexure had not been completely released from its lateral parietal peritoneal attachments. A fecal fistula closed within four days, but the patient might easily have developed a right subphrenic or subhepatic abscess which would have prolonged his hospital stay considerably. The other occurred in a patient with a left lower quadrant colostomy in whom supuration of the colostomy closure wound occurred secondary to osteomyelitis in the adjacent ilium. It also closed within a week.

PERFORATING WOUNDS OF THE RECTUM

It is generally accepted that there are two essential features in the treatment of a perforating wound of the rectum: First, the establishment of a colostomy, and second, adequate drainage of the perirectal space. It is also generally agreed that the colostomy should defunctionalize the rectum for that is the primary purpose of the colostomy. A difference of opinion arises as to what type of colostomy should be established. In my opinion, the vast ma-

sority of perforating wounds of the rectum can best be handled by mobilization of the sigmoid colon, complete division of the bowel at that point, and the approximation of the two sigmoidal loops by one or two rows of interrupted sutures to form a double barrel Mikulicz colostomy. Two objections to this view on perforating wounds of the rectum have been raised. It has been held by some that for severe wounds of the rectum, in order to defunctionalize the distal segment adequately, the bowel must not only be divided but brought out as two separate colostomies with a bridge of skin between the loops. I doubt if this is ever necessary except in those rare instances in which a large part of the rectal wall has been destroyed and a permanent colostomy must be considered. The amount of feces which will spill over into the distal segment from a double barrel Mikulicz spur with the bowel completely divided is negligible. It was not appreciable in any of the cases in this series and the rectal perforation healed satisfactorily in each instance. It must also be remembered that if the sigmoidal loops are separated, intestinal continuity will have to be restored by an end-to-end anastomosis.

The other objection that has been raised is that for small or moderate perforating wounds of the rectum, for questionable perforations of the rectosigmoid which can be securely closed and for wounds of the perineum, a loop type of colostomy with an opening made on the antimesenteric border is perfectly adequate. (Fig. 3a.) This type of colostomy is said to be more easily constructed and will more readily permit the restoration of these patients to limited duty in an overseas theater.

Among these 120 patients, loop colostomy of this type for perforating wounds of the rectum proved far from adequate in defunctionalizing the distal segment, and whenever a slowly healing rectal or perirectal wound necessitated the existence of the colostomy beyond five or six weeks,

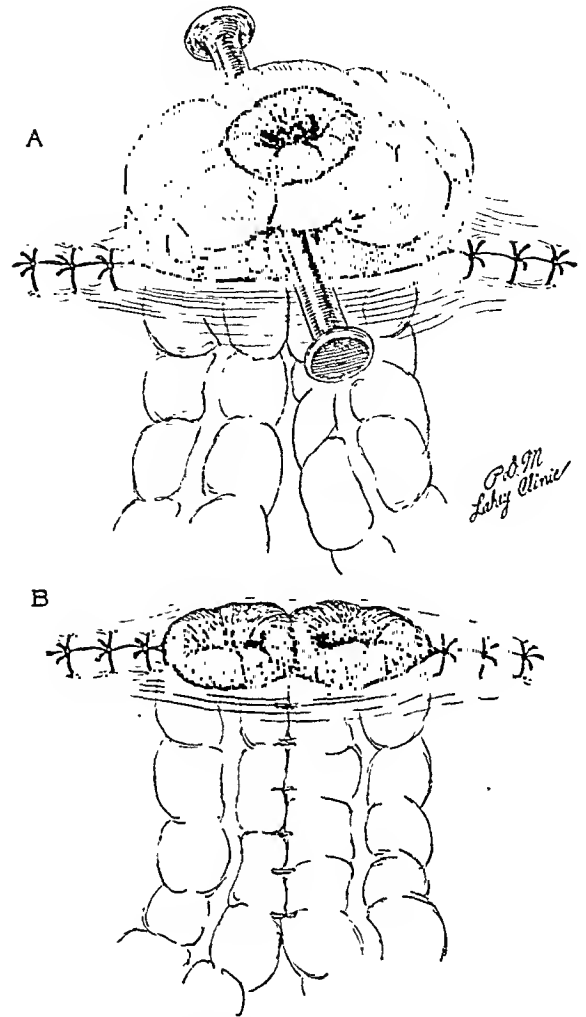


FIG. 3. A, a simple loop colostomy with incomplete division of the bowel. It will decompress but not defunctionalize the distal segment. If the limbs of the colostomy happen to fall fairly close together as shown, the bowel could be completely divided and later a crushing clamp applied to the spur, but great care must be taken that neither the mesentery nor loop of small bowel be caught in the clamp. B, double barreled Mikulicz type colostomy with complete division of the bowel. It will defunctionalize as well as decompress the distal segment and the spur can later be crushed, with no danger to mesentery or small bowel. It differs from A only in that the bowel has been completely divided between clamps and the antimesenteric borders of the two limbs united by six or eight interrupted sutures.

they showed an almost unanimous tendency to retract. Of the nine cases in this group in which a loop colostomy had been made for perforating wounds of the rectum, only one failed to accumulate feces rapidly or slowly in the lower rectal segment. In seven of the eight cases in which this occurred, the perforation remained unhealed eight weeks after the injury. Since in all

of these cases the colostomy was steadily retracting, permitting more and more feces to spill over, reconstruction of the colostomy had to be performed in order to keep the wound empty and secure healing of the perforation. The sigmoid was mobilized, the bowel completely divided and a double barrel Mikulicz spur constructed. Two conditions were present in each of these patients with non-healing of the rectal wound: First, an accumulation of feces inside the rectum and second, persistent suppuration in the perirectal wound in spite of adequate drainage. It may be argued that these loops were exteriorized under tension and undoubtedly in some cases this was true. Nevertheless, I believe there is a tendency for the partially divided loop colostomy, with no fixation except the glass rod originally placed under the bowel, to retract after a period of weeks.

When it is realized that mobilization of the colon is particularly easy in the redundant sigmoid region of which I am speaking and that the only additional step in the formation of a double barrel spur is that the two loops be left in sufficiently close contact that the adjacent walls can be crushed without injury to the mesentery or to the small bowel, it would seem that very little additional time or effort is required to construct this type of colostomy. It has frequently been possible to approximate the two loops by a crushing clamp and to do an extraperitoneal closure when the limbs have not been approximated by suture at all or when the limbs have been brought into close contact by approximating the ligatures on epiploic tabs. I believe that it is considerably safer and less painful to the patient when the clamp is applied if the antimesenteric borders are approximated by seven or eight interrupted sutures, uniting the adjacent longitudinal bands. (Fig. 3b.)

The problem of restoring these patients to limited duty depends largely on the type of individual concerned, the need for limited duty personnel in the theater, and

the presence or absence of intraperitoneal injuries which might predispose to the subsequent development of small bowel obstruction, so frequently seen in patients with perforating wounds of the abdomen.

The muscle and fascia of the abdominal wall were carefully approximated following the closure of each of these two types of colostomy and no instance of herniation was observed at the time of discharge following the closure of either loop colostomy or double barrel spur colostomy. During 1943 and early 1944, when the need for limited duty personnel was most marked, several of the patients in the first group were restored to various types of limited duty, such as corpsmen in general hospitals, guards at stockades and clerks in base section headquarters. They were all patients who had had an extraperitoneal closure of a double barrel colostomy.

It is frequently difficult in these patients to be sure that the rectal perforation is a small one; and if the size of the perforation cannot accurately be determined, it would seem desirable to construct a colostomy which will keep feces out of that rectum as long as it may be necessary. For small wounds of the rectosigmoid which can be securely sutured and for wounds of the perineum a loop colostomy might be perfectly adequate, but here the question must arise as to whether a colostomy is necessary at all.

The only difference of opinion concerning the second essential point in the treatment of rectal perforations, namely, the drainage of the perirectal space, is as to whether or not it is necessary to remove the coccyx. There were seven patients in this group in each of whom the coccyx was not removed at the time drainage was established. No instance of abscess formation as a result of inadequate drainage was observed, nor has it occurred in my previous experience with cases of this type in which the coccyx was not removed. The fundamental principle, however, is the adequate drainage of contaminated areas. If, because of the particular type of injury concerned

or because of limited previous experience with this type of injury, the operator believes that he cannot adequately drain the perirectal space without removal of the coccyx, he should by all means remove it. If, on the other hand, he believes that by dividing the fascia propria transversely at the tip of the coccyx, carrying the incision around into either or both of the levator ani muscles if necessary, then I think the coccyx is better left undisturbed.

It has been suggested that those patients in whom a draining sinus persists, leading down to the sacrum, are those in whom only a portion of the coccyx has been removed and the base has been left attached to the sacrum. If this proves to be true, disarticulation of the coccyx with removal of the articulating surfaces, as has been recommended, may eliminate this complication. The fact remains, however, that patients in whom the coccyx has been removed will henceforth have varying degrees of discomfort on sitting, and the projecting lower end of the sacrum may remain tender long after healing of the wound has occurred.

SUMMARY

In summary, in this last group of ninety-five cases there were thirty-six double barrel spur colostomies, fifty-five loop colostomies and four cecostomies. No instance of spreading peritonitis was seen after closure of the loop colostomy even though all were replaced in the free peritoneal cavity. No complications were associated with the clamping of the spur in the thirty-six double barrel spur colostomies. No patient required a secondary cecostomy following the closure of his colostomy, although in several patients with a loop colostomy on the left side, it was four to five days following closure before they were able to pass gas by rectum.

Eleven patients in this group were

evacuated to the United States with their colostomies not closed. Seven of these patients had rectal wounds which were not healed five to six weeks following their injury. The other four were evacuated early because of an especial need for hospital beds at the time, and each had associated injuries or complications which made closure of their colostomies a secondary matter.

There were no fatalities in the first group of patients. In the second group there were four fatalities. One patient died suddenly shortly after admission from an exsanguinating hemorrhage due to a divided gastroduodenal artery which had been overlooked at the time the perforation in his duodenum had been repaired and the perforation in his hepatic flexure of the colon exteriorized. A second died seven weeks following his original injury from generalized peritonitis arising from a series of abscesses secondary to a retracted cecostomy. Two large abscesses in the right lumbar gutter were drained but a third gave rise to peritonitis from which he failed to recover. The third patient died from a pulmonary embolus following laparotomy for an intestinal obstruction ten days after his colostomy had been closed. The fourth patient died several weeks after his original injury from persistent suppuration in the retroperitoneal tissues. He failed to respond to penicillin, chemotherapy and drainage of the infected area.

CONCLUSIONS

Marked progress has been made in military surgery during the course of the recent war. The lessons learned must not be forgotten. The problems raised must be followed through and the best solutions possible be found so that the military surgeon of tomorrow may begin not where the military surgeon of today began but rather well beyond where he finished.

REHABILITATION OF THE INJURED HAND

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BUNNELL makes the statement that "Next to the brain the hand is the greatest asset to man, and to it is due the development of man's handiwork."

Certainly, during this last war man has perfected much varied and mechanized equipment all demanding some degree of manipulation by hand and this, in turn, has increased the incidence of hand injuries. The instinct to protect one's face and to use the hands to help one to safety in the face of danger also subject them to a greater probability of injury. Indeed, it is hard to conceive that a person could be injured in combat who would not receive, also, some injury to his hands due to this instinct to protect himself. Injuries due to these causes augment the large number of hand injuries sustained in combat as the result of direct enemy fire.

The incidence of hand injuries which have come under treatment on the Plastic Surgery Service of this naval activity is ever increasing. A comparative estimate on this service at any one time would reveal that between 20 and 25 per cent of the total number of cases are injuries of the hand in one form or another. In a paper of this kind it would not only be impossible but space would not permit a detailed discussion of each case of hand injury including the preoperative and postoperative care in its rehabilitation. For this reason, a general picture of the entire group of cases will be our aim, together with the problems and the solutions incident to handling them. Typical cases in some of the main groups should be of interest in bringing out cardinal points and in showing the actual end results we would like to attain.

It is true that surgery in connection with the treatment of the injured hand is

difficult and many times, after long hours of labor, the results are disappointing. That is no reason to assume an attitude of dislike or discouragement, however, or to pass off all hand cases as though they were something to be accepted and for which little could be done except in only a very few selected cases. The satisfaction and the gratitude which the patients show when we do obtain the desired results should stimulate us sufficiently to overlook the cases whose end results are discouraging. I wonder whether any case was ever presented but that something could be done to better that condition, even if it were only some minor procedure which would satisfy the patient's desire and peace of mind even though it did not actually improve the physical condition of his hand appreciably.

The hand conditions as we see them in a general hospital here in the States are old, of course, and most of them are healed wounds. They have been treated at other stations along the line and have been sent back for definitive treatment. In our discussion, we are referring, in the main, to this type of hand and its rehabilitation.

One could classify the cases of injuries to the hand which come under our supervision and treatment, in a general way, by grouping them according to the predominant type of injury. Of course, in a classification of this kind there is always some overlapping since many cases present a combination of injuries and might fall into more than one group, but for the purpose of this discussion we make the following classification: (1) burns; (2) contractures of all varieties; (3) traumatic amputations of the digits; (4) lacerated tendons; (5) post-infectious deformities; and (6) multiple injuries, involving ten-

dons, nerves and bones. Problems of the purely neurosurgical and purely orthopedic types are not treated by the Plastic Surgery Division and are, therefore, not included in these cases.

Burns. This type of injury includes burns caused by all agents and chemicals which are capable of producing burns, as well as by electrical energy which produces a deep burn and involves all structures in its path as well as the skin. In the average third degree surface burn a dense cicatrix forms in healing which is thick, tough and unyielding and prevents normal function of the joints even in cases in which no apparent joint injury is involved. Most of our cases of burns of the hands were on the dorsum of the hands and fingers, but in several cases the palms, also, were burned with burn contractures resulting.

In deep burns of the hands there is an involvement of the tendons and joint capsules as well as the skin, and with subsequent contracture, this produces the typical burn contracture deformities of the hands with hyperextension of the metacarpophalangeal joints, flexion of the first interphalangeal joint, and, usually, hyperextension of the distal joints of the fingers. Contractures develop across the web spaces and prevent abduction and adduction of the fingers and thumb. Thus, the hand is bound in a rigid covering which, in time, becomes more contracted allowing less use of the joints. Certainly, it is desirable to treat these cases as early as possible after their initial injury and to supply a good skin covering at the earliest moment rather than to allow them to granulate and to develop extensive contractures or to allow healed scarred epithelium which is tense and thin to become excoriated with secondary ulceration.

Contractures of All Varieties. In this group we include all contractures of the hand due to various etiology: lacerations, penetrating objects, shrapnel and bullet wounds, in which soft tissue is the primary tissue injured and in which heavy scar

develops with healing. The contracture may be superficial and involve only the skin and subcutaneous tissue of the hand, or it may extend deeper and involve all the soft structures underlying it, including tendons. With healing, in these cases, contractures develop and produce deformities of either the flexion or extension variety, depending upon their site. Only one finger may be involved, or, if the contracture is extensive, several may be affected. Conservative treatment, including physiotherapy, seems to improve these conditions for a time, but usually the condition is not relieved permanently and surgery is ultimately required.

Traumatic Amputation of the Digits. Many of these patients, fortunately, have only one or two digits or merely parts of digits traumatically amputated, and a useful hand can be obtained with the remaining digits if the amputation stumps are covered satisfactorily. Usually the skin over the stumps is thin and atrophic or painful neuromas are present which prevent even light pressure on these areas. Frequently, because of pain, a patient will not use the other remaining functioning digits of his hand with resulting joint stiffness which further increases his disability. Surgery will relieve these conditions and even apparent lengthening of a short deformed digit can be obtained by deepening the adjacent web spaces.

Lacerated Tendons. We see a number of injuries produced by sharp penetrating objects which have healed more or less per primam but in which the original injury has divided the tendons, either flexors or extensors. In wounds in the field it is impractical to do primary tendon repair, and, frequently, because the wounds are dirty, it is inadvisable to repair them later at the station hospital even should the patient arrive within twelve hours, the so-called relatively safe period for primary tendon repair. This gives the patient an annoying condition of inability to use his finger or fingers which constantly get in his way in the ordinary

use of his hand. The condition, however, is very amenable to treatment and the patient can have function restored with usually satisfactory results by the surgical procedure of secondary tendon repair with tendon graft. A technic of tendon grafting is described herein.

Post-infectious Deformities. All wounds of the hand, if left open, are contaminated but fortunately most of them heal without apparent extensive infection. There is a group of cases in which virulent infectious processes develop with destruction of tissue and resultant deformities, many of which are contracture deformities of a general nature. Usually many incisions must be made in the course of the original treatment at the time of the acute infection in order to establish drainage. The infectious process destroys the smooth gliding action of the tendons if these sheaths are invaded and adherent useless tendons result. Joint destruction, also, is a frequent complication. Thus a digit or, perhaps, all the digits cease to function; general nutrition is disturbed; and the entire hand becomes painful and useless as far as function is concerned.

Multiple Injuries Involving Tendons, Nerves and Bones. There is a large group of combat injuries in which the injury is extensive and all the various tissues are involved to a greater or lesser extent. These cases are combination problems of the neurosurgeons, orthopedists and plastic surgeons and the problem is one of restoring all remaining structures to as near a functioning status as possible. Extensive surface scarring is usually present and the circulation is impaired. It is necessary to replace the surface covering with a pedicle graft after the scar has been excised. This improves the general condition of the hand. The orthopedic and neurosurgical problems should be corrected before the final tendon reconstruction is undertaken.

In evaluating the extent of damage of an injured hand, a history of the condition together with the previous treatment

is essential. This takes time and patience on the part of both surgeon and patient, and frequently a hasty diagnosis as to the condition becomes disappointing to both surgeon and patient alike when the end results are tabulated. Immobilization of a part over a period of time produces atrophy and functional disability which sometimes makes the present picture appear more extensive than is actually the case. It is of paramount importance to make a very careful examination of the entire extremity as well as the injured hand. Local signs may have remote causes. The general condition of the hand should be observed, including the circulation, general state of nutrition and the atrophic changes. The general picture should then be outlined. Each part of the hand is checked separately for motion, pain and sensory disturbance. X-ray examination is imperative to check bone changes and deformities. The disability is noted and studied, and the anatomical basis for it worked out. This is important from the standpoint of diagnosis and evaluation and, also, from that of its correction. When one is able to visualize the pathological condition, one is able to outline the procedure to be followed in the rehabilitation of the hand and to give a prognosis. Certainly, one is not justified in subjecting a patient to the ordeal of an operative procedure which is long and laborious and will offer him only little possibility of improvement. By reviewing the condition carefully, the surgeon is able to avoid this in most cases. If the hand is nothing more than a non-functioning mass of painful scarred tissue resulting from wounds and subsequent infection, one would be performing a surgical feat rather than a sound surgical procedure to even attempt to rehabilitate it. Perhaps, amputation with prosthesis would be the solution.

Preoperative Treatment. After elective operative procedure is decided upon, certain preoperative care is necessary. The original injury must be well healed. No induration or reaction of tissue to healing



A



B

FIG. 1. A and B, preoperative photographs showing heavy dense burn scarring approximately five months after injury.

should be present. In the case of a tendon injury, three to six months should elapse before secondary repair. When the initial wound heals per primam, it is sometimes advisable to go into the hand within two months so that the divided tendons may be brought together, but in most of the severe hand injuries there will still be induration of tissues and stiffness of joints.

This is best taken care of by physiotherapy. Good joint motion is essential and until tendons can be repaired for

active joint motion, passive motion with physiotherapy must be carried out. Physiotherapy also improves the circulation which, in turn, increases the nutrition of the hand so that induration disappears and scar tissue softens. In cases in which heavy scarring is binding and acts as a constriction—a condition which interferes with nutrition—a preliminary operation is necessary in which the scar tissue should be removed and good tissue covering supplied in the form of a pedicle graft. Our aim is to restore function and good

sensation and, certainly, these cannot be restored ultimately without first improving the nutrition of the hand. Frequently, joints are painful and, perhaps, temporary splinting will be necessary before physiotherapy is begun. This will quiet the joints which otherwise might be aggravated if physiotherapy were applied to them.

The patients are encouraged to take occupational therapy also as an adjunct to physiotherapy. In this way they do manipulations which are fairly complicated but they do them while interested in the projects on which they are working, which minimizes the constant reminders to move the joints. Thus, joint movements and active muscle exercises are carried out effectively and without conscious effort. This preoperative treatment prepares the patient for surgery and enables the surgeon to make a better evaluation and prognosis of the case.

OPERATIVE TREATMENT

Hand surgery is always difficult even when optimum operative conditions are available. Good lighting and suitable draping material, of course, are necessary. The hand should have a so-called "sterile" preparation which consists of shaving, soap and water scrubbing with trimming and manicure of the finger nails, and should then be washed in alcohol and wrapped in sterile towels the afternoon before the operation. The operative field is prepared using routine skin antiseptics.

General anesthesia is our anesthetic of choice, and most of our operative procedures are performed under sodium pentothal anesthesia.

It is essential to use a tourniquet during the dissection stage of the surgery in order to provide a bloodless field in which to work and not to damage important structures as well as to aid in making a clean anatomical dissection. An ordinary blood pressure cuff is used over a band of cotton, care being taken to apply the tourniquet snugly and smoothly. The blood pressure cuff is supported with gauze

bandage and an Esmarch tourniquet is used to express the blood in the hand and forearm before inflating the cuff. While the Esmarch tourniquet is in place, the blood pressure tourniquet is inflated to between 240 to 260, and, after clamping the tube to secure the pressure, the Esmarch tourniquet is removed and the operation is started.

Incisions are made in the hand and on the digits along the flexion creases and not over points of pressure. Mid-lateral incisions are made along the digits. Good exposure should be obtained without unnecessarily long incisions. It is extremely important to be gentle in retracting skin flaps and in handling normal structures in order not to traumatize the tissue, thus minimizing the formation of postoperative scarring. All scar tissue should be removed if subsequent tendon work is to be done, or if it is to be done at the same procedure. Meticulous care in handling uninvolved tendons should be exercised to prevent scarring or damage to their gliding mechanism.

These are all small points, and yet a great difference is noted in postoperative results for their observance. The technic of tendon grafting and suturing employed is included in this article in a case report.

After exploration and exposure of the pathological condition, the procedure is decided upon. If it is found that bone or joint conditions are involved, that work should be corrected first either by the orthopedist or by the surgeon if he is equipped to handle the situation. At a later stage the nerve and tendon repair can be done in that respective order.

If extensive scar tissue is present and the skin is adherent to underlying structures, a pedicle graft is used to cover the defect after excision of the scar. The pedicle graft is usually turned up from the abdomen in cases in which the palm of the hand is involved and turned down from the abdomen in cases in which the dorsum of the hand is involved. This provides a good covering and subcutaneous

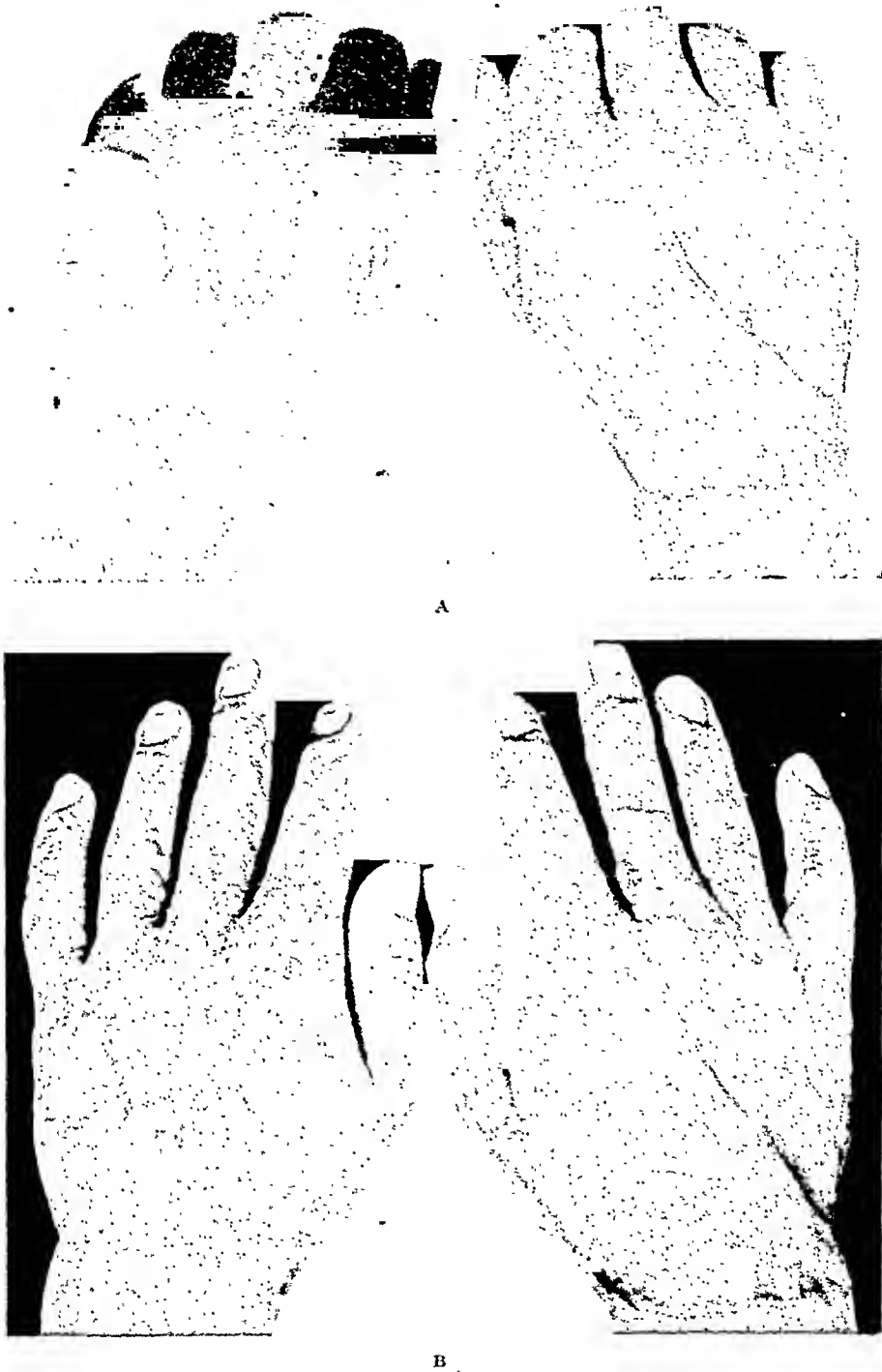


FIG. 2. A and B, final postoperative photographs taken approximately two months after last skin grafting procedure.

fat under which tendons can glide and also healthy tissue to replace the scar, thereby improving the general nutrition of the hand. Subsequent operations for nerve work or tendon grafting can then be approached through healthy tissue.

After the dissection is complete, the tourniquet can be released and the bleeding points ligated. Frequently, during the dissection, vessels which are cut can be

ligated at the time, thus avoiding unnecessary bleeding. After hemostasis is secured, tendon grafting or whatever procedure is contemplated can be done. If it is desirable to do this work under the tourniquet, it can be reapplied in the same manner as previously described. It is well to remember that after release of the tourniquet pressure should be maintained on the wound with moist sponges

FIG. 3.



FIG. 4.



FIG. 3. Preoperative photograph showing contracture deformity.
FIG. 4. Attachment of abdominal pedicle to hand.

for five minutes because of the initial hyperemia. This saves unnecessary clamping of oozing points and then only active bleeders need be secured.

After the operation is completed, careful closure of the wound is necessary using subcuticular sutures and small suture material for skin closure with many closely spaced sutures. The suture material which we generally use is fine silk for ligatures and subcuticular sutures and fine silk for skin closure. A pressure dressing is always necessary in hand surgery to prevent undue oozing and hematoma from developing postoperatively. This can be accomplished by applying fine meshed gauze to the surface of the wound and fluffed gauze which can be compressed with gauze bandage. If fixation of the part is necessary, a molded plaster or metal splint can be applied. The dressing need not be excessively bulky so as to lose the effectiveness of the splint.

The operative procedure for excision of burn cicatrix of the hands and skin grafting is done under the same conditions as any other hand surgery. A tourniquet is used when scar tissue is dissected away. The scar tissue is excised completely down to a good base, care being taken not to expose the tendons but allowing the peritendinous tissue to remain so that the gliding motion of the tendon is preserved and its function is not disturbed. Usually the burn does not involve the tendon except in cases of very deep burns or electrical burns. The grafting procedure and the dressing are included in detail in a case report.

POSTOPERATIVE TREATMENT

Elevation of the limb postoperatively for any surgery done on the hand is essential in order to minimize postoperative discomfort and swelling. Inspection of the wound can be done about seven to



FIG. 5.



FIG. 6.

FIG. 5. Pedicle after revision.

FIG. 6. Double exposure photograph four months postoperatively showing range of motion.

ten days postoperatively by opening the bandages without disturbing the hand and forearm from its splint. Sutures can be removed at this time and the dressing folded together again and re-bandaged. Elevation of temperature, pain and throbbing sensation in the hand, of course, call for inspection of the hand at any time. The primary dressing after grafting can be done on the sixth to the tenth day at which time the sutures and skin overlap can be removed.

In the case of tendon work, fixation of the hand in plaster for three weeks without motion is maintained and support is then given by elastic bands. Then physiotherapy can be started. The patient is encouraged to move his hand actively immediately after its removal from the

cast with elastic traction used as a safeguard against sudden pull on the healing structures. In skin grafting procedures for burns under the usual conditions of "take," motion can be started within two weeks.

Physiotherapy for periods of months is essential postoperatively before final results can be evaluated. Improvement can be expected for six to twelve months or perhaps even longer. Occupational therapy to engage the patient in intricate manipulative work and hand exercises are all very essential. Good physiotherapy treatments with the patient's full cooperation are essential for good results.

CASE REPORTS

CASE I. A Typical Burn Case of Hand Injury: This case involving the entire dorsum



FIG. 7. Showing the ends of the flexor tendons exposed. A, distal end of the flexor digitorum profundus; B, proximal end of the flexor digitorum profundus; C, proximal end of the flexor digitorum sublimis; D, digital nerve and vessels.



FIG. 8. View showing incision made in the wrist. Involved flexor digitorum sublimis tendon isolated under clamp.

of both hands and fingers is a typical burn case. The patient sustained third degree burns of both hands in a gasoline explosion aboard ship. The granulating areas were allowed to epithelialize and on admission to this station all areas were healed. Heavy burn contractures were present over the dorsal surfaces of the hands and fingers preventing full flexion of the metacarpophalangeal and interphalangeal joints of the fingers and thumb. (Figs. 1 and 2.) Grafting of the right hand was done five months after the burn; each hand was done at a separate operation. The entire scar tissue was dissected away using a tourniquet and sodium pentothal anesthesia, care being taken not to remove the peritendinous tissue. Incisions were made in the web spaces to deepen them. The tourniquet was released and hemostasis

secured with No. 0000 white deknatel silk, and the tourniquet re-applied while the skin graft was sutured into position. Split thickness skin grafts of .018 inch thickness cut with a Padgett dermatome were used to cover the denuded surface. Darts were cut in the graft over the web spaces and sutured into place in the denuded areas between the fingers. Suture material used was No. 0000 black deknatel silk. Approximately one and three-fourths dermatome drums of skin were used for the right hand and approximately one drum of skin for the left. Unless the webs are deepened and grafted, contractures will develop across them. In spite of this procedure, minor corrections of the web are often necessary, as was true in this case. A pressure dressing was applied consisting of a single layer of xeroform gauze over which were



FIG. 9. The flexor digitorum sublimis tendon has been pulled through and is to be used as tendon graft to establish continuity between divided ends of the profundus. It is divided at the wrist and proximal end allowed to retract.



FIG. 10. Proximal suture of tendon graft complete.



FIG. 11. Distal suture line of tendon graft completed.



FIG. 12. A thin, veil-like piece of tissue from the fascia lata of the thigh has been secured and wrapped around the tendon graft in its entire extent as well as beyond the suture lines. It is fixed in position using fine silk sutures.

placed moistened saline sponges and machinist's waste secured with gauze bandage with the hand and fingers in a flexed position. After the dressing was completed, the tourniquet was released. In using the tourniquet the graft site is bloodless; hematomas do not form under the graft while it is being sutured in place or before the pressure dressing is applied.

The "take" of the grafts was practically complete. The primary dressing was done on the sixth postoperative day, at which time all sutures and overlaps of skin graft were removed. Daily dressings using light pressure were done thereafter. Physiotherapy treatments were started about the fifteenth postoperative day.

The same operative technic was employed on both hands, with the left one being grafted about one month later. A minor grafting procedure was done to the web spaces between the thumb and index finger of the right hand and between the fingers of the left hand about two months later.

A good covering replaced the heavy burn scar and full function of the hands was restored.

CASE II. Contracture Deformity of the Hand: This case demonstrates a contracture deformity which was deep and involved the flexor tendons. While the case is relatively simple, involving the flexor tendons to one finger, it includes the principles of repair which might apply if the entire hand were involved in the same condition. The patient received lacerations of his hand across the distal palm on its ulnar side and proximal portion of his little

finger with division of the flexor tendons near the base of the finger. Primary tendon repair and digital nerve suture were done and, with healing, scar tissue formed and contracture resulted with flexor deformity of the little finger. The finger was carried in about 50 per cent flexion. There was no active flexion action present in the interphalangeal joints.

The first plastic procedures were done one year after injury under sodium pentothal anesthesia and using a tourniquet. All scar tissue in the finger and the distal palm was removed as well as the scarred part of the flexor tendons, leaving the proximal ends of the flexor tendons free in the palm and the distal end of the unscarred flexor digitorum profundus tendon free in the finger. The insertion and the adjacent proximal inch of the flexor digitorum sublimis tendon was removed since it was involved in the scar tissue. An abdominal pedicle



FIG. 13. Repair completed; reconstructed restraining ligament shown.

was used to cover the defect. The pedicle was divided fifteen days postoperatively and a final revision done later. Active physiotherapy was started fifteen days after the pedicle was revised to keep the joints in active condition.

Four months later a tendon graft was done to establish continuity of the flexor digitorum profundus tendon to this finger. The distal portion of the flexor digitorum profundus tendon was exposed by an incision along the lateral attachment of the pedicle graft on the little finger. The proximal ends of the flexor tendons of this finger were exposed through an incision in the distal flexion crease of the palm and the tendon graft was done using the flexor digitorum sublimis tendon.

The tendon graft was sutured using the Bunnell method of tendon suture with fine silk. The wounds were closed using fine silk as subcutaneous sutures and closely spaced interrupted sutures of fine black silk for skin approximation. A pressure dressing using fluffed gauze was applied and the hand was fixed in a plaster splint with flexion of the wrist and normal flexion of the fingers for three weeks postoperatively. The wounds were inspected by unfolding the dressing on the tenth postoperative day when the sutures were removed. The dressing was again secured.

When the cast was removed the patient was allowed to move his finger as much as he was able with active motion. A light elastic band connected with a thread through the finger nail and attached to the wrist protected the finger from too forcible extension. This remained in place for one week and was applied only at night for one more week. Physiotherapy was started the fifth postoperative week. Four months later the function had been restored to about 75 per cent of the normal range. (Figs. 3 to 6.)

The following series of photographs show the

technic of tendon grafting used. It will be noted that this series of photographs are not those of the actual procedure done in the case report but demonstrate a similar condition of tendon grafting where the ring finger was involved. (Figs. 7 to 13.)

COMMENTS

Rehabilitation of the injured hand is in most instances probably one of the most difficult tasks which the surgeon is called upon to perform. By careful examination and planning, together, with meticulous surgery, this work can be accomplished with satisfactory results in many cases. Good cooperation on the part of the patient in taking active hand exercises and following physiotherapy treatments is most essential for good results.

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BONE SURGERY OF THE HAND

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THE severely mutilated hands caused by the havoc of war have left many types of residual deformities and dis-

without tendon action. Bone surgery itself was not indicated unless it would restore added usefulness to the hand, and it had



FIG. 1. A, loss of thumb and first two fingers; B, transfer of third metacarpal onto greater multangulum.

abilities to be dealt with. In civilian practice these were comparatively rare. On the Orthopedic Service at the Valley Forge General Hospital many such hands were encountered.

Bone surgery of the hand is the restricted title of this paper because inclusion of the associated surgery of the skin, tendons, muscles and nerves would be far too comprehensive and may be dealt with separately. It should be clearly understood, however, that in nearly all of these cases bone surgery played only a part, and sometimes but a small part, in the rehabilitation of the hand.

Before any surgery was begun on the hand a most careful evaluation of its prospective function was made. For instance, a finger without sensation was a pretty useless prospect unless the nerves could be restored. So also was a finger



FIG. 2. A, shrapnel riddled scar full of scar tissue; B, bone block between first and second metacarpals to hold thumb in opposition.

to be considered always in relation to the whole.

Needless to say surgery of the bones could not be performed on the hand through scar tissue. Good skin with subcutaneous tissue was a necessary prerequisite for this work. In deep hand wounds, such as are illustrated here, nearly always a full thickness skin graft was needed. This was done by the plastic service beforehand, either by local or

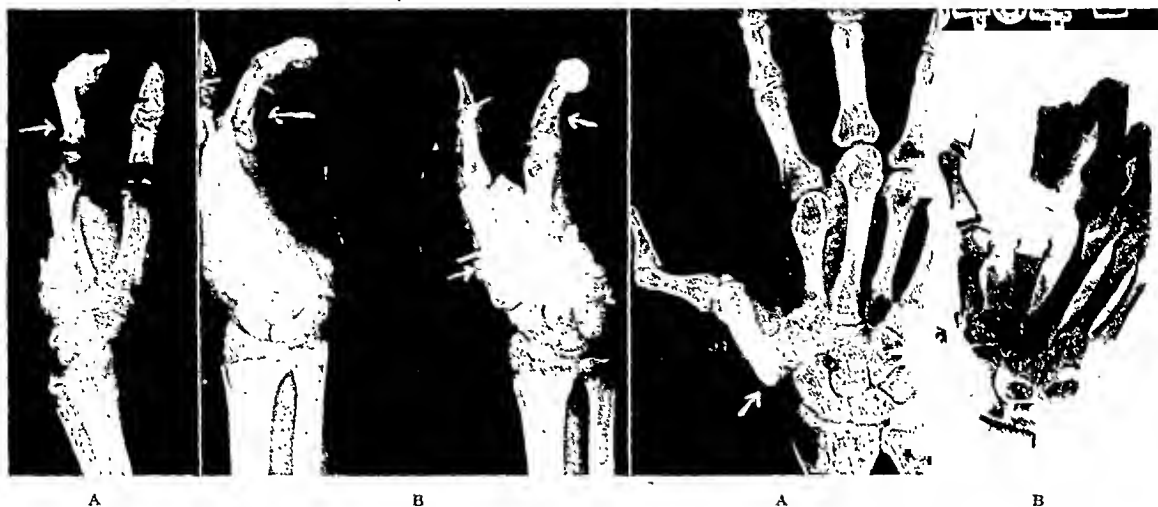


FIG. 3. A, loss of three fingers plus mal-union of phalanx of index finger and loss of opposens power in thumb; B, rotation osteotomy of first metacarpal to aid opposens action and correction of alignment of phalanx by osteotomy.

FIG. 4. A, dislocation of first metacarpal; B, reduction.

remote flap methods. After this was accomplished it was important to decide upon the next surgical procedure. Usually the bone work came after the skin grafting because it formed the basic structure upon

each such procedure a considerable interval of active use was given to restore the function of the hand as far as each intermediate step would permit.

THUMB

Loss of a thumb could sometimes be partially compensated for. If just the two phalanges were gone, the web between the first and second metacarpals was deepened, and a fair grasping and holding digit was shaped out of the first metacarpal and the thenar tissues. Three or four successful cases of this type confirmed the usefulness of this plastic procedure.

However, when the first metacarpal was also gone, a far more serious handicap resulted because a hand without a thumb is quite useless. Therefore, some type of thumb reconstruction was worth while. Case 1 illustrates how such a problem was met. Fortunately in this patient, a large amount of soft tissue had been preserved and the second metacarpal was available for a bone graft because the index finger had also been amputated. This useless metacarpal was transferred over to the thenar side and set into the greater multangulum. In the event that this metacarpal had not been available a tibial graft could have been used.

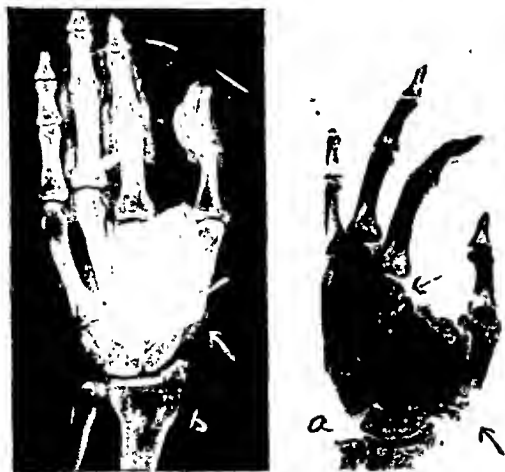


FIG. 5. a, dislocation of first metacarpal and part of greater multangulum and also 90-degree angulation of third metacarpal fracture; b, reduction of first metacarpal with excision of blocking remnants of second metacarpal; mal-alignment of third corrected later.

which to build the action of the fingers. Occasionally, nerve grafts or neurolysis were performed earlier or at the same time as the bone work. Tenolysis, tenorrhaphy or tendon grafting were sometimes also performed with the bone surgery. Between

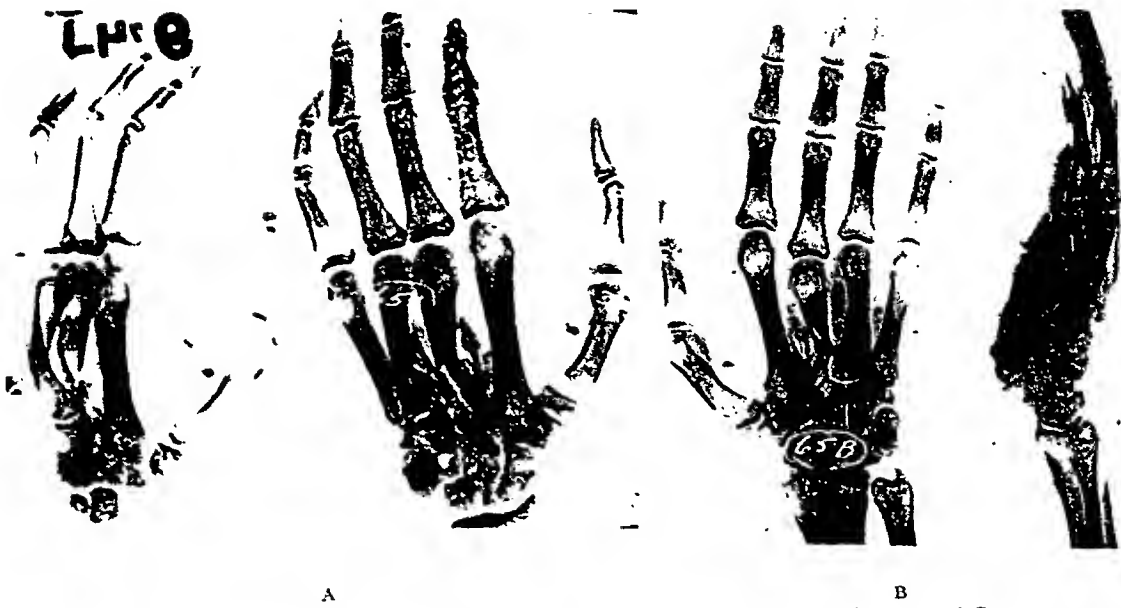


FIG. 6. A, dorsal angulation of metacarpal fractures; B, correction with improved flexion at metacarpophalangeal joints.

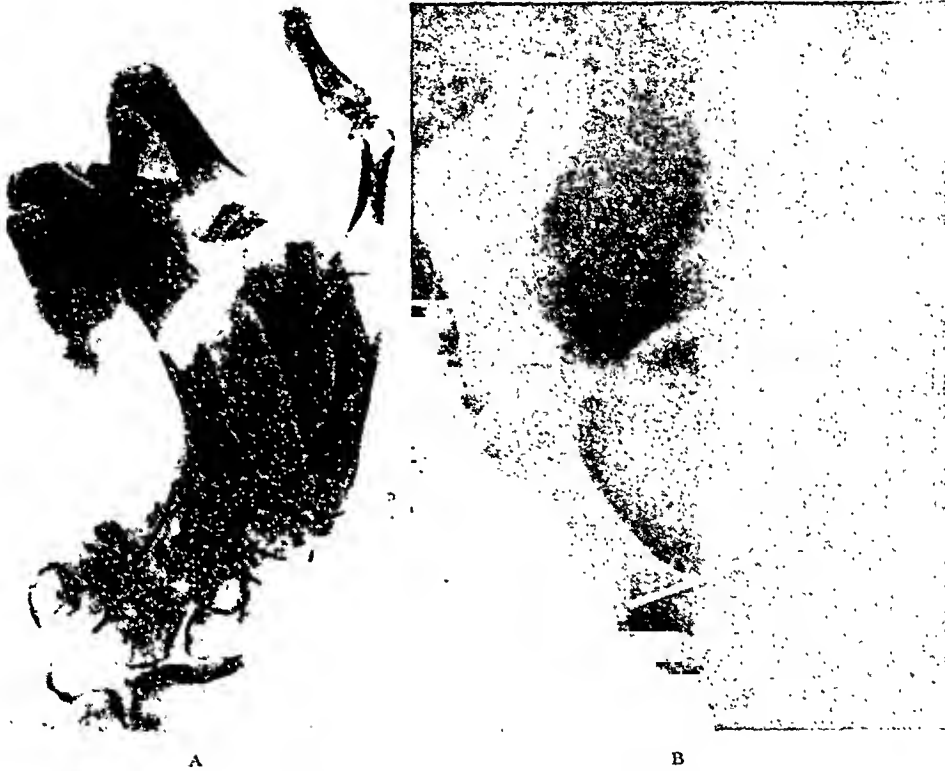


FIG. 7. A, loss of fourth and fifth fingers with mal-union of the second and third metacarpals; B, corrected alignment of metacarpals.

The loss of the opposition action of the thumb in Case II, was caused by the destruction of the thenar muscles and a dense scar contracture. This was overcome by freeing the scar and bringing the thumb around into an opponens position. To hold it there a small bone block was taken from the tibia, was wedged down between the first and second

metacarpals and held in place by a Kirschner wire. A similar problem was met in Case III, when opposition of the thumb was also lost because of scar tissue contracture. In this instance the thumb and remaining finger possessed fair flexor and extensor power and after freeing the scar an osteotomy was performed at the base of the first metacarpal and the shaft rotated.



FIG. 8. A, non-union of fourth metacarpal; B, dual bone grafts.

This permitted it to move into a position of opposition to the index finger when later a tendon transplant was done to motivate it.

Dislocations of the base of the first metacarpal were not uncommon. Obviously a thumb could not function when the first metacarpal had slipped up into the wrist as in Cases iv and v. The reductions were not easy but they were held in place

by Kirschner wires and fortunately they did not tend to recur when the wires were removed in five or six weeks.

METACARPALS

Malunion of metacarpal fractures could be a real problem. Case vi was an example of the severe handicap which often followed the dorsal angulation of the metacarpals.

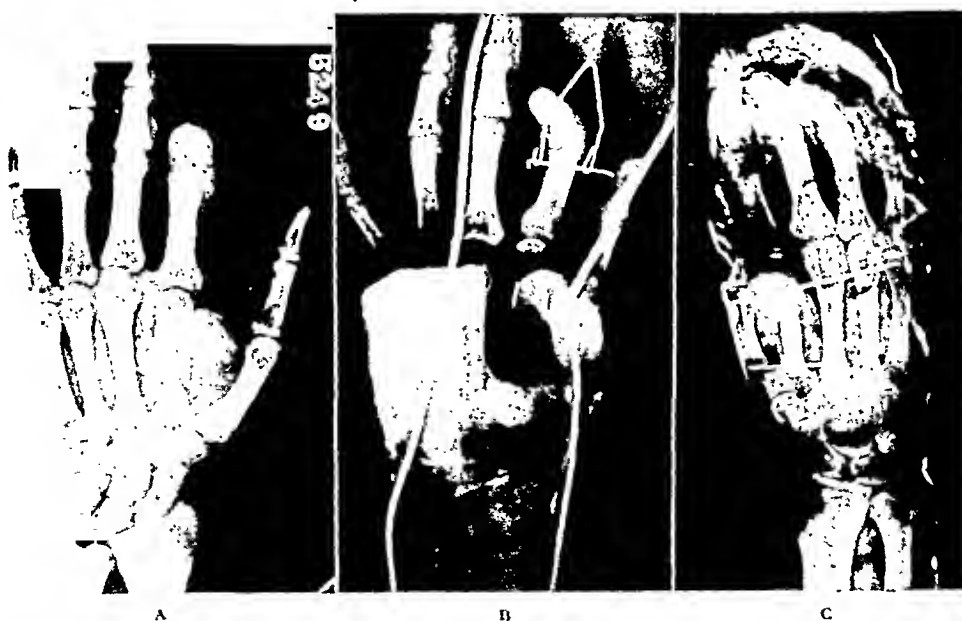


FIG. 9. A, non-union of second metacarpal; B, skeletal traction to restore length of finger; C, tibial bone graft notched distally to match shaft and doweled proximally into base.



FIG. 10. A, non-union of fifth metacarpal and mal-union of proximal phalanx of fourth finger; B, tibial bone graft notched into proximal shaft and doweled into phalanx, sacrificing the joint; corrective osteotomy on phalanx performed later with flexor tendon graft.

In such a position the heads of the metacarpals had dropped forward and the whole intrinsic muscle mechanism of the fingers was thrown out of gear. This resulted in severe extension contractures of the metacarpophalangeal joints which were intractable, despite forced use and many types of traction apparatus. True lateral x-ray views were helpful to illustrate this deformity and the correction of this malalignment was well worth while, although the final result was tempered by whatever residual deficiency existed in the intrinsic mechanism. It was often necessary at operation to do a capsulectomy on the collateral ligaments of these joints in order to obtain 90 degrees of flexion and also to run Kirschner wires through the heads of several metacarpals to hold them up in place until healing occurred. Further it was found advisable postoperatively to maintain the metacarpophalangeal joints in a position of 90 degrees flexion for two or three weeks in order to prevent the recurrence of these extension contractures. At the same time active use of the pha-

langeal joints was encouraged to prevent stiffness of the fingers.

Lateral angulation of the metacarpals also left a deformity which had to be corrected. Case VIII shows a terribly mutilated hand with complete loss of the fourth and fifth fingers along with their metacarpals. The second and third metacarpals were grossly distorted but their alignment was corrected as shown in the illustration.

BONE GRAFTS

Non-union with loss of substance of the metacarpal was a common finding. A number of cases are presented to illustrate the different types of bone grafts which were used to fill in these defects. Case VIII shows one of our earlier types. Two small dual grafts were used in order to grip both open ends in a vise which was held by a screw. Further experience developed two simple and more satisfactory methods of matching the grafts with a fair degree of self fixation. When

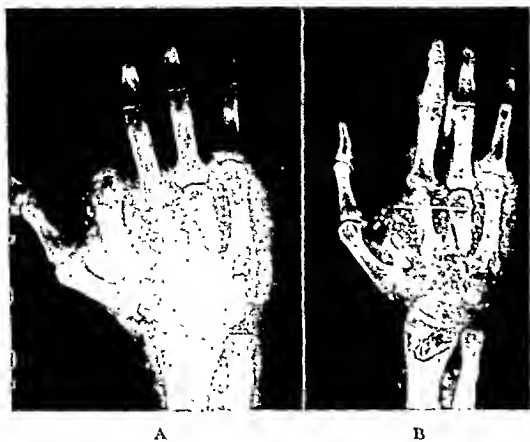


FIG. 11. A, useless remnant of index finger with loss of head of second metacarpal; apparent non-union of their metacarpal but at operation it was found to be firmly united; B, removal of second metacarpal and transplant of distal half of fifth metatarsal onto shaft of third metacarpal after restoration of joint space.

the head or the base of the metacarpals was involved a hole was gauged into it and the end of the graft was doveled to fit and was then tapped in snugly. In fractures of the shaft of the metacarpal the donor and recipient ends were notched in opposite planes with a small rongeur so that they locked firmly when jammed together. One or two Kirschner wires were usually inserted transversely through normal and fractured bones to give added strength to the fixation.

The closer to the normal length the metacarpals could be restored, the better was the ultimate function of the hand. Therefore, if there was any hope of stretching out the distal end, preliminary skeletal traction was used as in Case ix. A partial restoration of length was accomplished and then a graft was inserted. Case x also illustrates an earlier experience with a bone graft from the tibia to replace the loss of the distal half of a metacarpal. In this instance the joint was sacrificed in order to provide bony support to the finger.

Such a disadvantage from sacrificing a metacarpal-phalangeal joint of an important finger led us to the experiment of Case xi. This officer had been completely blinded, and his finger function was truly important. The index finger was already



FIG. 12. A, loss of fourth and fifth metacarpals and carpal bones leaving intact fingers with sensation and tendons; B, v-shaped bone graft.

missing so that its metacarpal stump was removed to eliminate scar and to make a smooth cleft between the thumb and middle finger. The space formerly occupied by the head of the third metacarpal was filled with dense scar tissue which had to be meticulously dissected out and a soft tissue covering prepared. The distal half of this fifth metatarsal was then borrowed for the graft and was notched into the proximal end of the metacarpal and fixed with a Kirschner wire. It seemed worth while to try this procedure because previous experience had shown such uniform success in metacarpal grafts. This single contact graft grew perfectly and the joint moved well. The flexor tendon had remained intact. Later after union of the graft and motion in the joint had been well established, an extensor tendon graft was added and the finger functioned very well.

The problem of complete loss of the fourth and fifth metacarpals as well as some of the carpal bones was met in Case xii. Here the index and middle fingers were badly damaged by scarring and stiff joints. Ironically, the fourth and fifth fingers were left in good condition with intact tendons and nerves despite the missing metacarpals. A v-shaped bone graft was inserted to support these fingers.

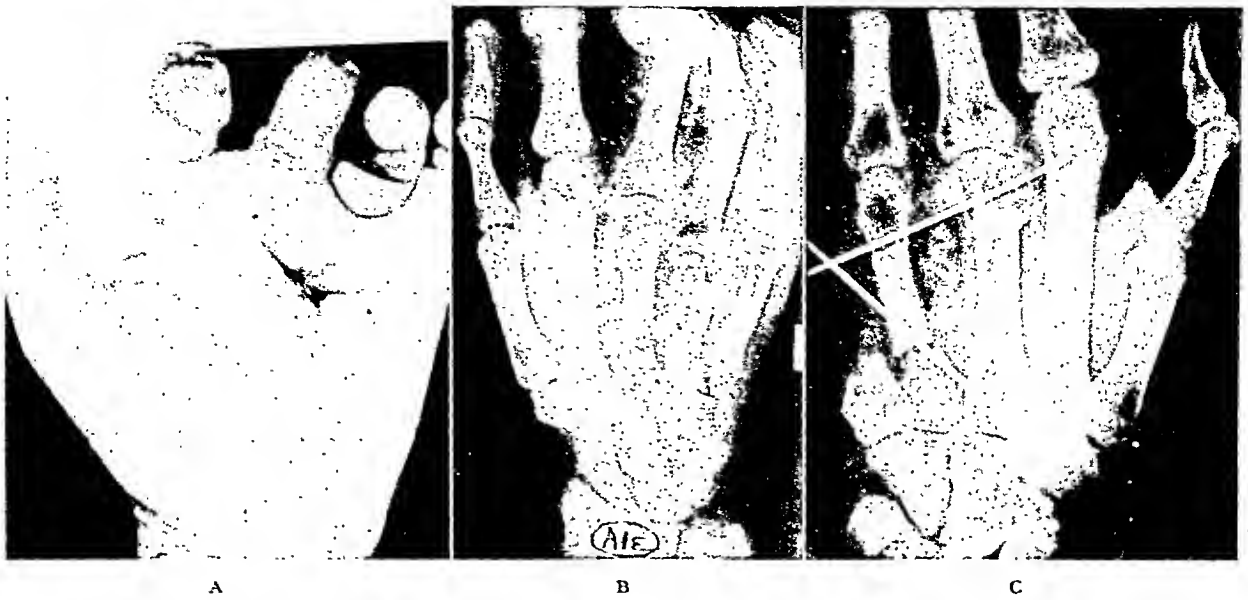


FIG. 13. A, palmar scar; B, loss of half of fourth metacarpal plus loss of sensation and tendons in finger; C, elimination of fourth finger with its metacarpal shaft and transfer of fifth metacarpal onto base of fourth.

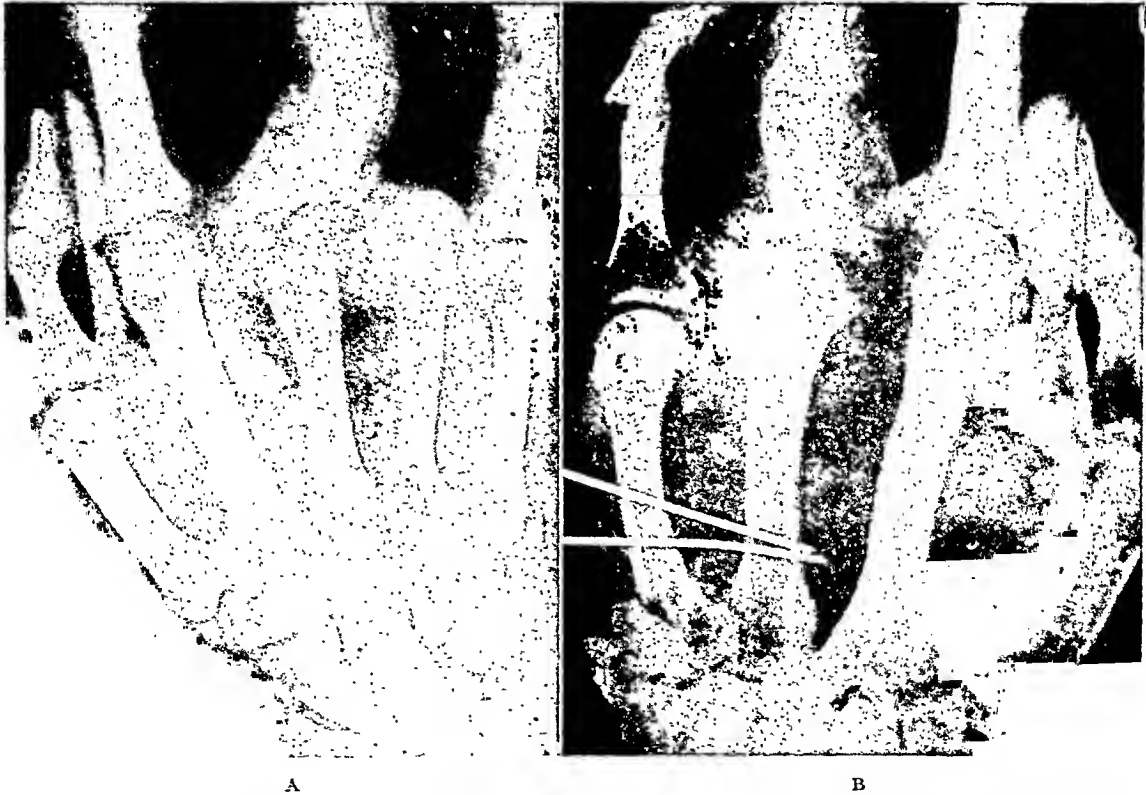


FIG. 14. A, loss of fourth finger with deformity of third metacarpophalangeal joint surfaces; B, excision of shaft of fourth metacarpal and transplant shaft of fifth onto its base; arthroplasty of third metacarpophalangeal joint.

TRANSFER OF METACARPALS

Many times the loss of one finger has had an adverse effect on the intrinsic muscle mechanism of the adjoining digits. Scar contractures intervened and oftentimes the abnormal flexor pull angulated the finger. To counteract this effect it seemed wise several times to "close" the hand by

shifting the metacarpals. Cases XIII and XIV show two instances in which the fifth metacarpal has been shifted over on to the base of the fourth. The problem in Case XIII can readily be appreciated. The distal end of the fourth metacarpal was missing and the finger was without nerve and tendon supply. So it was sacri-



FIG. 15. A, front of split hand; B, dorsum—third metacarpal missing; C, transfer of second metacarpal onto base of third to close split.

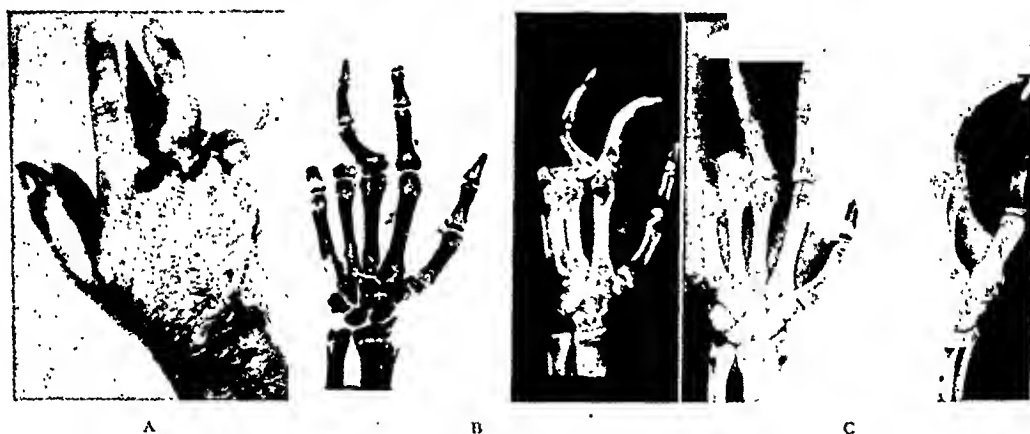


FIG. 16. A, mutilated hand with bad scarring which had to be excised; B, deformity of proximal phalanx of middle finger; C, correction by osteotomy.

ficed and the fifth finger was moved over to take its place by shifting that metatarsal over on to the base of the fourth. Enough skin and soft tissue were thus made available to excise the palmar and dorsal scars.

Case XIV was similar except that the ring finger was already missing. The fourth metacarpal was removed and the fifth was shifted over on to the fourth base.

On the other side of the hand in Case XV, the second metacarpal was shifted over onto the base of the third in order to close a cleft hand. The result in all of these transfers depended upon the quality of the remaining intrinsic muscles and varied inversely with the amount of scar tissue present. In general this operation was found to be a definitely helpful procedure for the proper indications.

ARTHROPLASTY

Numerous arthroplasties of the metacarpophalangeal joints were done and one is shown in Case XVI which also had the transfer of the metacarpal. The base of the first phalanx was trimmed up neatly and the sleeve mechanism around it adjusted. In other cases the deformed heads of the metacarpals were reshaped. The results in both these types of arthroplasties of the metacarpophalangeal joints were quite good. Plastic cups were tried but were found to be unnecessary in so far as preventing adhesions, and to have the active disadvantage of slipping around. The most important factor was discovered to be the preservation of an even balance in the intrinsic muscles and freedom of the

sleeve mechanism so that the finger did not tend to angulate to one side when flexed.

The successful graft of the metatarsal head with its intact cartilaginous surface into the metacarpophalangeal joint in Case XI, led to the surmise that this procedure could be carried along to further usefulness in restoring damaged metacarpophalangeal joints. Arthroplasties of the phalanges were not successful as a rule because they left unstable joints. Whenever necessary, such damaged joints were fused, especially in the little finger, at the optimum position of 45 degrees of flexion.

OSTEOTOMIES

A rotation osteotomy of the first metacarpal to bring the thumb into opposition was shown in Case III. A second glance at this case will show that a rotation osteotomy was also done on the first phalanx of the index finger to correct angulation. Case V had an unusual mal-union of 90 degrees of the metacarpal shaft fracture which had to be corrected to improve the function of the metacarpophalangeal joint. In Case X a successful osteotomy of the proximal phalanx of the fourth finger was performed in order to prevent the finger from flexing away out of line, and at the same time a flexor tendon graft was implanted successfully. Case XVI likewise shows clearly the advantage of an osteotomy for a deformed phalanx. The scar was excised, the mal-union broken up and this finger straightened out very well. The method of fixation after these osteotomies was usually to insert short ends of Kirschner wires either obliquely or longitudinally through the ends and leave them until union occurred.

CARPECTOMY

An extreme condition of flexion contracture (Volkman's type) of the fingers and wrist followed a lesion of the brachial

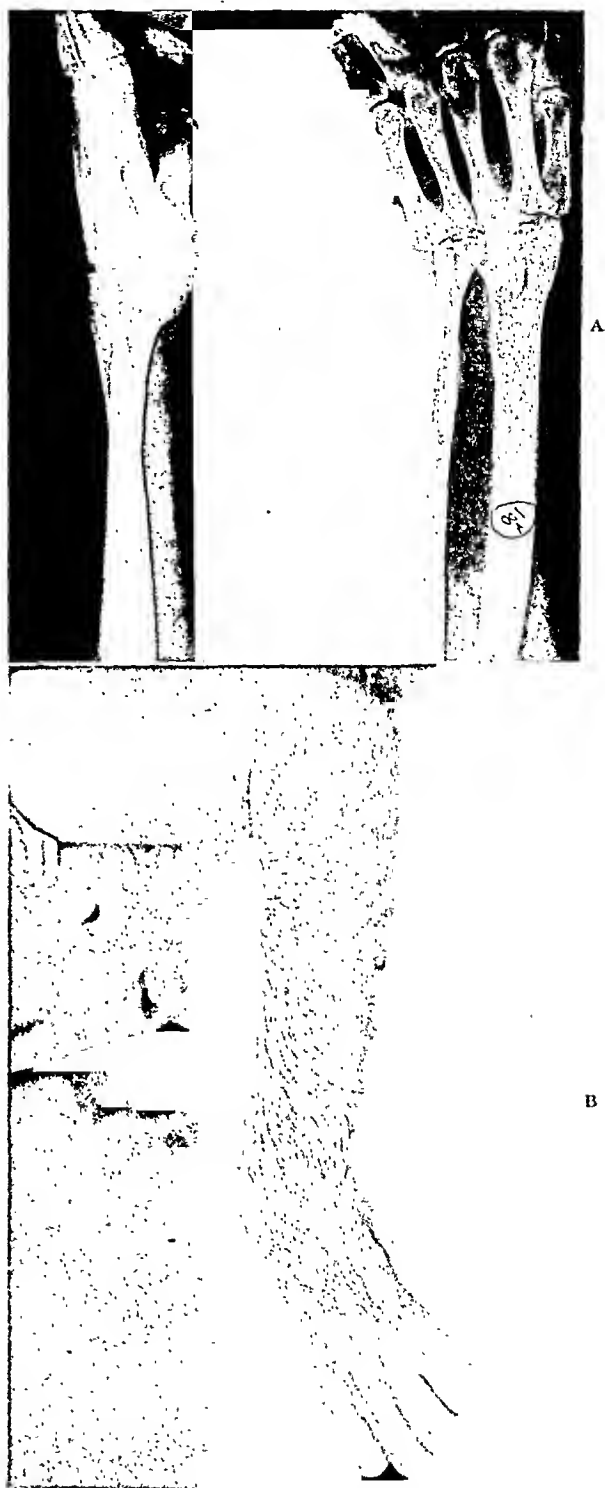


FIG. 17. A, severe ischemic contracture of wrist and hand; B, tendon length obtained by carpectomy; functional position by fusion of hand to radius by sliding bone graft from radius into third and fourth metacarpals.

artery and radial nerve in Case XVII. Sufficient tendon length for fair finger action was obtained by a carpectomy. A sliding bone graft from the radius across to the third and fourth metacarpals fixed the hand in a functional position so that

the weak muscles could exert fair power on the fingers.

SUMMARY

Many deformities and handicaps of the hand require bone surgery of different types. Bone grafts have been used to form a first metacarpal, to make a bone block between the first and second metacarpals, and in many varied forms to make up loss of bone substance in metacarpals. A metatarsal head with its cartilaginous covering was successfully transplanted onto a metacarpal shaft to form a new metacarpophalangeal joint.

Mal-union of metacarpals often required correction by osteotomies to realign the metacarpal heads and restore the intrinsic muscle function. Rotation osteotomies

were also useful to correct mal-union of both metacarpals and the phalanges.

Closing in of the hand by metacarpal shifts onto the bases of their vacant neighbors was discovered to be an advantageous procedure under proper indications.

Simple arthroplasties of the metacarpophalangeal joints were practical and reasonably successful.

CONCLUSION

A series of hand problems have been presented in which various types of bone surgery have accomplished an improvement of function in severely deranged hands. Practically no failures of union have been noted either after osteotomies or bone grafts.



REPAIR OF AVULSION WOUNDS OF THE HANDS AND FEET BY THE FLAP GRAFT TECHNIC

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THE treatment of avulsion wounds of the hands and feet in a general hospital functioning in the Mediterranean theatre of operations during World War II presented definite problems which necessitated a closure technic providing a thick fatty skin cover within the shortest period of time. All of these wounds were either penetrating or perforating; tendons, nerves and bones were exposed. In most cases the bones were fractured and often fragments were missing. While many of the cases were clinically clean immediately after débridement at evacuation hospitals, all were contaminated and many were infected by the time the general hospital was reached. Unless covered with a skin layer early, exposed tendons and bones soon became necrotic. To prevent further loss of the deep tissue structures, and to provide for the earliest functional results, all skin grafting technics were investigated.

The free grafts, Thiersch, split skin and full thickness could not take over the above mentioned deep structures. A fat containing pedicle type of graft was consequently indicated which would (1) cover exposed bone, tendon or deep irregular muscle defects, (2) not adhere to the underlying structures, and (3) not contract excessively.

Three such types of tissue covers were available; the contiguous skin flap, the tube and the flap grafts. The contiguous skin flap or the utilization of the tissue adjacent to the wound was limited because of the relative immobility and inelasticity of the tissues of the hands and feet due to the paucity of subcutaneous fat. This was especially true for large wounds.

The tube graft was an ideal technic for covering but required at least three, and

more often, additional operations to cover a defect. To decrease the number of the operations required the flap graft was reinvestigated and used instead of the tube graft.

The flap graft repair was first described by the Indians who used the forehead as a donor site for the repair of facial wounds. Tagliacozzi in the sixteenth century, made use of the arm as a donor site for similar repairs. This general method of skin transfer remained the common form of grafting up to the beginning of this century when Filatov tubed flaps to allow transfer of large amounts of tissue, usually from the chest or abdomen, to distant parts of the body. Except for certain types of cases, the flap graft was gradually discarded for the tube graft.

TABLE I
AVULSION WOUNDS OF THE HANDS AND FEET

	Flap Re- pairs	Combined Flap and Split Skin	Split Skin
Hands.....	34	0	15
Feet.....	12	3	14
		Total flap repairs 49	
		Total wounds 78	

As the name implies, the flap graft is simply a flap of skin, subcutaneous tissue and fat which is raised from a relatively non-functioning area and while maintaining its nourishment through an attached base, is sutured on three sides and its undersurface to the defect. When sufficient blood supply from the defect site has entered the skin graft, the flap is severed from the donor site and becomes part of the new location.

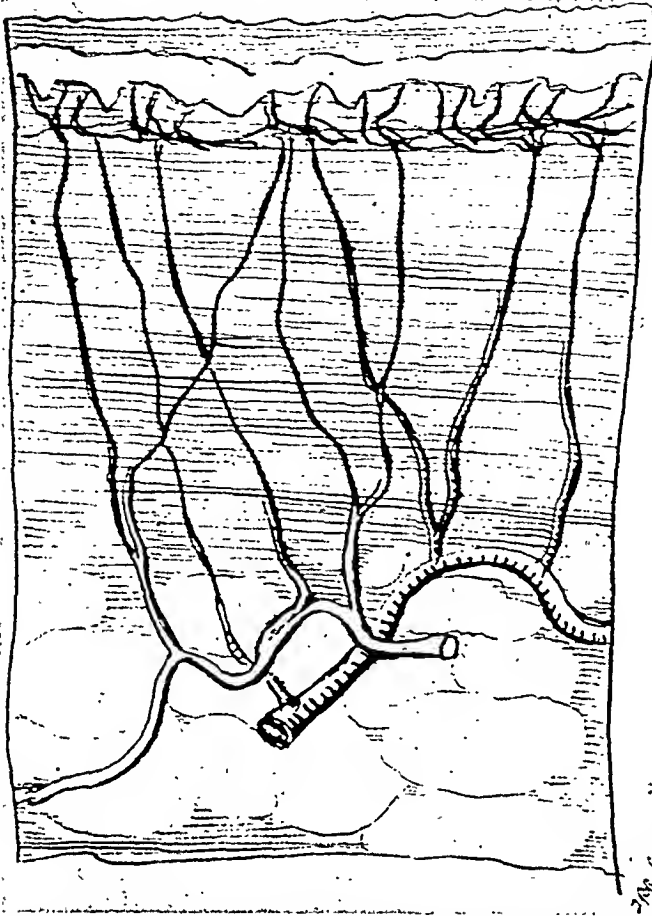


FIG. 1. Diagram of section through skin. Diagram illustrates the location of the large vessels in the fatty tissue. One can see how thinning the flap could easily cut the blood supply.

Wounds of the hands and feet presented defects which could be brought to the donor sites with relative ease obviating the necessity for tubing. An ideal situation was thus presented for the use of the flap graft.

TECHNICAL CONSIDERATIONS

Donor Sites for Hand Defects. The usual donor site was the abdomen. Practically all flaps were cut with the pedicle facing posteriorly or diagonally superiorly, so as to allow the lower thoracic and posterior lumbar vertebral vessels to enter the flap. On occasion when indicated, the flap base was directed superiorly or inferiorly with the source of blood supply coming from either the thoraco-epigastric vessels or the superficial iliacs coming up to anastomose with them. At no time were flaps cut across the midline since the vessels of the abdominal

wall do not go beyond the linea alba. The flaps were thick and included all layers of skin and fat down to Scarpa's fascia; this fascial layer was not included in the flap. All deep blood vessels were definitely included by this procedure. (Fig. 1.) The bulkiness of the graft was not considered at this time since the cosmetic factor was considered unimportant. The fat, if trimmed at all, was carefully cut so as to avoid vessels of any size. In some of our early cases, while attempting a cosmetic as well as a functional result, neglect of this important fact led to edge necrosis. The size of the flap varied considerably; we did not exceed the rule of "length no more than three times the width" but always tried to get the widest pedicle possible. The flaps cut were larger than the defect only because the pedicle of the flap had to bridge the gap

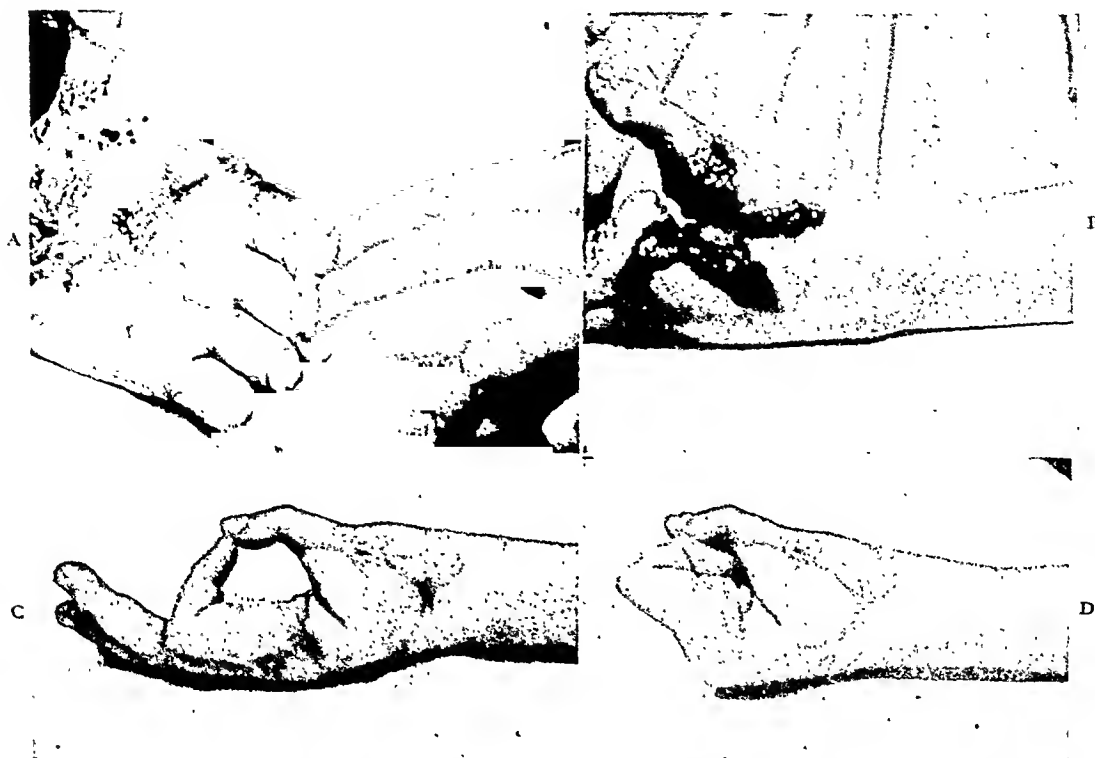


FIG. 2. Marked avulsion wound of the first web space, with comminuted fractures of the first phalanges and the first metacarpal. Tendons, both extensors and flexors of the first and second fingers were exposed. There was a loss of part of the tendons of the first finger. Wounded by shrapnel, the wound was débrided the same day. The patient was admitted to General Hospital fifteen days later. On the twenty-third day, he was seen by the plastic service and accepted. On the twenty-fifth day a second débridement was done, necrotic tendon was trimmed and the wound was greatly decreased in size by undermining and sliding contiguous flaps. On the twenty-ninth day the hand was attached to an abdominal flap and severed from the abdomen on the forty-third day. On the sixty-third day a fusion of the first metacarpal phalangeal joint and the interphalangeal joint was done because of non-union. The hand healed rapidly thereafter and the patient was placed to a duty on the 103rd day. Illustrations show the resulting function. Had the patient been seen by the service sooner, many days in time would have been saved.

between the donor site and the defect. The graft size had to include, therefore, an easily mobile pedicle as well as the defect. A loose pedicle was important to avoid pull on the graft when the hand was placed on the abdomen. The part sutured to the defect was placed with normal skin tension, since we believed that an oversized graft would contract and compress the small vessels causing venous stasis. An undersized graft under tension would strangulate the entering blood supply and cause arterial avascularity and necrosis.

Donor Sites for Foot Defects. The anterior, lateral and medial aspects of the thigh were chosen as the best donor sites for the foot defects. In most cases the base of the flap was placed in the superior direction. However, in cases in which the defect

was on the lateral aspect of the foot or ankle, a retrograde flap was raised, the blood supply coming from the rich plexus of vessels about the knee.

In search for a more comfortable donor site, the lower leg was considered but found unsuitable for several reasons. The subcutaneous tissue contained little fat, a limited blood supply, and lacked contour for large defects. Another disadvantage was the lack of silent areas on the leg. Any flap raised would uncover tendons or bones, which in turn would have to be covered by a fatty layer. Still another disadvantage was the disturbance of the sensory nerves when tissue was removed; this was not only annoying to the patient but might make him susceptible to further trauma. An additional disadvantage was the possibility

of vasomotor disturbances often associated with surgery of the legs. Some people have a high vascular tone and are sensitive to vasoconstrictor effects of cold, pain and trauma. The operation of lifting a flap and then placing the leg in a confining cast for any length of time can be followed by a serious increase of vascular constriction, so serious in some cases as to cause necrosis of tissue when least expected.

TABLE II
DISTRIBUTION OF HAND DEFECTS REPAIRED BY FLAPS

	No. Cases
1. Segments of fingers only.....	8
2. First web space.....	6
3. Dorsum only.....	7
4. Combined dorsal and volar flaps for perforation.....	2
5. Dorsal flap only for severe perforation.....	1
6. Defects post-amputation with exposures of bones and tendons.	
a) Longitudinal hand amputation of 1st metacarpal and thumb.....	2
b) Longitudinal amputation of 5th metacarpal and 5th finger.....	2
c) Longitudinal amputation of 4th and 5th metacarpals and 4th and 5th fingers	1
d) Horizontal amputations of Nos. 3, 4, 5 fingers, exposing heads of metacarpals.	1
e) Amputation and exposure 2nd metacarpal; loss of skin dorsal and volar surfaces.....	1
f) Same as above only 3rd metacarpal involved.....	1
g) Same as above only 4th metacarpal involved.....	1
h) Same as above only 5th metacarpal involved.....	1

When there was doubt in our minds as to the circulation of the flap, either because of the position or the size, we resorted to the delaying technic. The technic of delaying is merely the principle of a gradual rather than a sudden reduction in blood supply.

The ideal technic called for two delays. The primary consisted of two parallel lines along the side of the flap, cutting down to deep fascia and undermining along the entire size of the required flap. The second stage was the connection of these two lines. Lifting the whole flap on all sides but the

base in one stage might cause necrosis at the distal end because of lowered blood supply. The cutting of the blood supply from its sides and from below forced dilation and engorgement of the blood vessels coming through the base pedicle. The vessel arrayed themselves longitudinally and enhanced the circulation for the eventual transfer. We usually waited seven days before the next stage.

All flaps raised were of a single pedicle type. A double pedicle would have sacrificed mobility of flap tissue, making it difficult to cover the extremity wounds; then, too, the early repair of the donor site would be hampered, since undermining and closure of the flap defect site when attached on two ends could be difficult. Lastly, since the extremity would have to be placed under a double pedicle flap, the flap itself would have to be cut much larger to accommodate the thickness of the extremity.

Recipient Site. Only frankly necrotic tendon and bone were surgically removed before a flap was placed over the defect; infected tendons were not débrided. If x-ray showed an osteomyelitic process in comminuted pieces of bone, the pieces were removed at a secondary débridement. All granulation and early scar tissue was removed, making sure there would be no barrier for new blood vessel penetration. Fresh skin edges were cut and then slightly undermined to facilitate suturing to the flap. Since many wounds were of the bursting as well as the lacerating type, the size of the defects could often be decreased by undermining the adjacent skin edges, sliding or rotating that tissue and then suturing. Not only did this decrease the size of the flap to be raised, but also gave a regular edge to the wound. In some of the large foot defects, it was thought advisable to decrease the size of the defect because of the difficulty in obtaining sufficient flap from the thigh. We combined a flap and split skin technic. Since the tissue of the foot does not lend itself to contiguous sliding or stretching, a heavy split skin graft (.024 of an inch) was taken by dermatome and

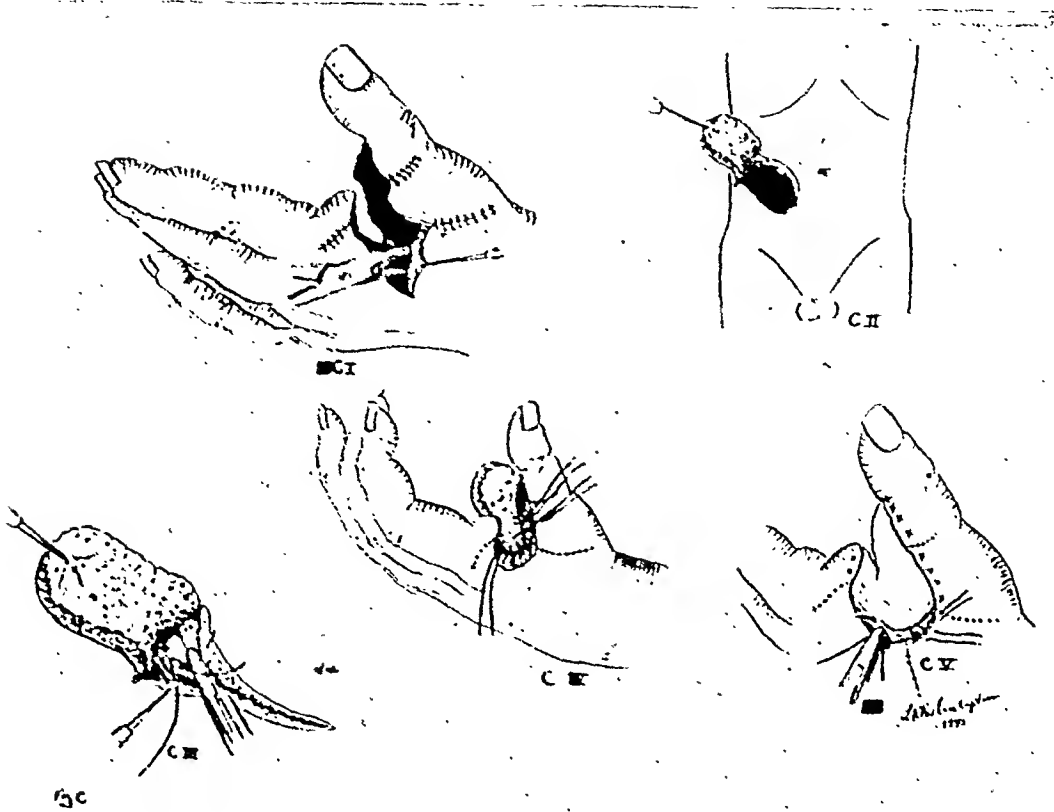


FIG. 3. Illustrations showing the technic of flap application. CI shows the hand defect being decreased in size. CII shows the abdominal flap being raised, all layers of the fat down to Scarpa's fascia. CIII illustrates the closure of the abdominal donor site prior to application of the flap. CIV demonstrates the placing of deep sutures from the fatty underside of the flap to the depths of the wound of the hand. CV shows the final closure of the flap, using the skin subcutaneous suture described in Figure 5.

"pasted" by the gum acacia technic¹ on the superficial "silent" part of the wound, where there were no exposed tendons or bones. After seven days, when the graft was firmly taken, the flap was then sutured into position to cover the rest of the defect. It was customary at the first stage to raise and delay the flap on the thigh.

OPERATIVE TECHNIC

Hand Flap. After the hand defect was débrided and perhaps decreased in size, a tourniquet being used to get a bloodless field, a pattern was made by placing a piece of sterile paper or lead foil over the wound and cutting it to shape. The hand was brought over to the abdomen so that the direction and the size of the flap, including the pedicle, could be marked out on the abdomen. The hand was then withdrawn and the flap lifted in the manner described. With the flap protected by a layer of gauze saturated in saline, the defect left by the

flap raising was partially closed by marked undermining along Scarpa's fascia and then sliding or rotating the edges together with little to moderate tension; deep sutures of No. 00 catgut were used. The closure was made up to the base of the pedicle, taking care to avoid constriction of the base. A small uncovered area was always left near the pedicle; this was left open until the final repair. The skin was then closed with cotton or silk interrupted sutures.

The flap was now ready to be sutured to the defect; the hand was brought over to the abdomen again. Suturing of the flap to the hand began with the use of No. 20 cotton sutures running from the skin on the most superior edge of the defect to the underlying fatty tissue proximal in the flap; ties were knotted on the skin edge. To anchor the fatty part of the flap to the deep uncovered structures, progressive layers of No. 00 catgut sutures were placed

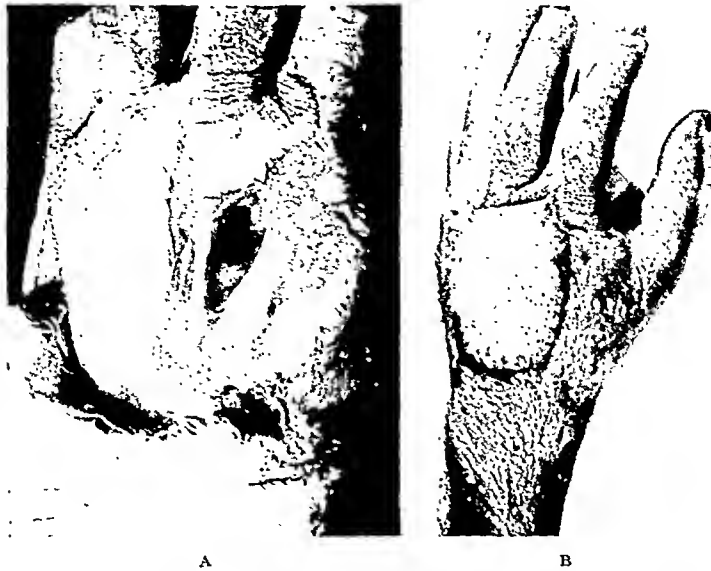


FIG. 4. A and B, pre- and postoperative pictures of a severe perforating wound of the hand, requiring a dorsal flap only. At the time of flap attachment, the wound was decreased in size by undermining. About one-fifth of the third metacarpal was removed at the time of débridement. The entire second metacarpal was exposed in the wound and was also fractured. While the dorsal second and third tendons were exposed, the patient could perform well with the second finger and have flexor motions with the third finger after the flap was attached and the wound healed.

from the fatty underside to the depths of the defect, obliterating the dead space. It was often difficult to find a good suture hold in the depths of the wound, but all attempts were made to have the fat in direct contact with exposed bone and tendon. At this time a narrow rubber tissue drain was placed deep in the wound to the outside, allowing for any accumulative drainage. The pedicle was inspected last to insure freedom from compression.

Foot Flap. A similar technic was followed for the defects of the foot. The closure of the thigh donor area often presented additional problems, since the skin of the thigh is not as abundant or mobile as the abdomen. Extensive undermining had to be employed. When the flap was very large and the closure impossible, a partial closure was done; the final healing was completed by applying a split skin graft when the flap was detached three weeks later. To insure the proper position of the flap, the foot was first brought over to the thigh and exact size and position marked; while suturing the flap to the foot defect,

the assistant held the foot in the correct position at all times to prevent pull on the flap.

Postoperative Fixation. Fixation presented several problems. In hot climates plaster of paris or adhesive was associated with uncomfortable sweating and skin irritability. The hand fixations were ultimately placed in a balanced traction under a Balkan frame, as shown in the Figure 10. Although this required that the patient remain in bed for three weeks, the final results and the great comfort were compensating factors.

A plaster of paris hip spica was the only fixation that was suitable for the foot flaps. The padded spica was applied immediately after the operation, the assistant or the surgeon himself holding the foot in the correct position to insure that there be no tension on the pedicle. Because of the abnormal position of the foot and the weight of the spica, ample reinforcement of the cast was obtained by adding braces. (Fig. 11.) A window was cut in the cast as soon as the plaster set; this was important

for observing the pedicle and the flap. If, because of shifting the position unknowingly, there was tension on the pedicle, the cast would have to be removed and then reapplied.

Postoperative Course. The only dressing applied to the flap was a layer of boric acid ointment gauze strips; the exposed fatty undersurface of the pedicle was covered in a similar manner. The wounds were inspected each day, the drains loosened and finally withdrawn by the fourth day. There was usually a moderate exudate present from the exposed fatty pedicle and the donor site, but this could be readily cleaned with alcohol and redressed with boric acid strips. While the hand wounds were no problem, the foot defects, because of access only through the window cut in the cast, could not be cleaned far down around the donor sites. However, that seemed to make no difference toward the final results.

The hand cases suffered no discomfort at all from the balanced traction, having freedom of movement without any body encumbrances. The foot spica cases complained of severe muscle spasms for two days or so, but responded favorably to morphine or codeine; by the third day the discomfort was minimal. To help the patient move about with his cast, a Balkan frame with handle bars for gripping was set up.

On the twenty-first day after the attachment of the flap, the pedicle was severed in one stage and the defect completely closed. The donor site was completely repaired at this time by applying a split skin graft if necessary. Almost all of the abdominal defects could be closed by undermining. Many of the thigh sites were closed by the combined closure and graft methods.

Anesthesia. Practically all the hand cases were performed under brachial block anesthesia; the abdominal flaps were blocked with novocaine 1 per cent without adrenalin. All the foot flaps were operated upon under procaine spinal anesthesia.

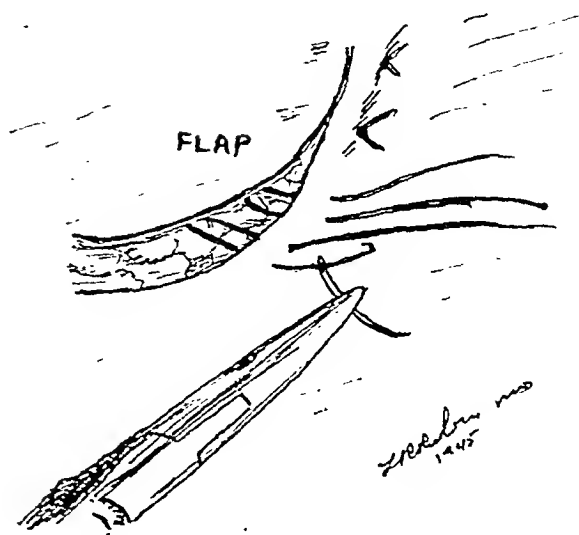


FIG. 5. Illustration of the final skin suture which prevents cutting off of the flap circulation. The defect edge is undermined a bit. The cotton suture goes through the defect skin, taking in all layers up to the fat. The suture then passes through the subcuticular tissues only of the flap and returns to the defect skin in a similar manner as first inserted. When tied on the defect side, there is no cuticular cutting or compression by the sutures.

COMMENT AND ANALYSIS OF RESULTS

There can be little doubt as to the necessity of grafting exposed tendons and nerves with a fatty cover. Since past experiences have shown that such uncovered deep structures became necrotic unless covered early, we attempted flaps even when they were infected. We had hopes of avoiding further destruction. To have procrastinated would have meant months of delay before the deep wounds could heal by secondary intention; during this time infection and necrosis would continue to spread through exposed bones and tendons to contiguous tissue with disastrous results to function.

The principle of Colonel Churchill⁵ on multiple blood transfusions and penicillin protection for improved wound healing has enabled us to bring the patient up to optimal condition. We even dared to cover wounds heretofore considered surgically unsound. Every patient had his hematocrit and hemoglobin brought up to normal. During the early stages of exposed tendons and bones and during the first few days after the application of the flap, penicillin (25,000 units) was given every three hours.



FIG. 6. Wound of Achilles tendon, with exposure and three-quarters loss of the Achilles tendon. The tendon was partially necrotic; a flap graft covered the defect. Above the flap can be seen a split skin graft covering a superficial wound defect.



FIG. 7. Severe avulsion wound of dorsum of foot with fractures of second, third and fourth metatarsals. The lateral one-half of the foot was considered a silent area and was covered with a split skin graft .024 of an inch. The medial part of the wound was covered with a heavy flap.

Occasionally, after using the necessary precautions in raising a flap and suturing, we were doubtful about the circulation. These cases were subjected to the fluroscene test, as described by Boyd and Lange.⁴ Briefly it consisted of the intravenous in-

jection of 10 cc. of 5 per cent fluroscene and viewing the flap under a special filtered ultraviolet light having a wave length of 3,600 u. If the attached flap showed a color change from deep purple to a golden hue, the circulation was good. Any dark

area in the flap indicated some nutrient obstruction and necessitated suture loosening or replacement of the flap in some way to avoid tissue necrosis.

Our early flaps were attached fourteen days before being severed from their donor sites; several patients had skin edge necrosis and in one case about 50 per cent of one flap was lost after severance. After six cases, we extended our attachment time to twenty-one days and thereafter had little trouble. The increase in time also obviated the necessity for partial flap severance and so avoided an extra operation.

Excluding burn cases, we had seventy-eight cases of avulsion wounds of the hands and feet which required grafting. Forty-nine of these cases were deep wounds with exposure of tendons and bones or both. The majority had compound, comminuted fractures associated with the wounds. These forty-nine patients were grafted by the flap graft technic; thirty-four were cases of wounds of the hands, while fifteen foot defects were closed in the similar manner. Of the latter, three flap grafts were combined with split thickness free grafts over the superficial "silent" parts of the wounds. Table I shows distribution of the cases and the types used.

Forty per cent of the cases when first covered with the flaps showed some degree of mild cellulitis which cleared within three days. We believed that the presence of a drain into the depths of the wound permitted the drainage of some accumulated material and helped the graft take. Four cases went on to frank pus drainage and had to have clamps inserted under the flap to remove a piece of necrotic tendon or bone; the grafts healed uneventfully thereafter.

Two cases had through and through wounds of the hands with skin avulsion on both dorsal and volar surfaces. With over-enthusiasm, we laid a double flap from the abdomen, covering the dorsal and palmar defects of the hand at the same time, as in a sandwich. In each case we had a cellulitis followed by drainage of pus; we had to de-



FIG. 8. Perforating avulsion wound of hand, with partial loss of #4 metacarpal, both extensor and flexor tendons #4, exposure and fractures of #3 and #5 metacarpals, exposure of #3 and #5 flexor tendons. After admission to the service, the fourth finger was removed and the hand narrowed. A combined dorsal and palmar flap was laid down at the same time. Because of purulent drainage, the dorsal flap was detached allowing sufficient drainage and healing of the palmar flap. When the palmar flap was severed from its pedicle, the dorsal flap was reattached with good healing of the hand.

tach the dorsal flap and allow it to fall in its original bed. In both of these cases, the volar defects were larger in extent than the



FIG. 9. Avulsion loss of the os calcaneus with skin defect. The upper one-half of the wound was covered with a split skin graft, .024 in. thickness, and one week later the flap was applied to the defect.



FIG. 10. Balanced hand fixation showing the plaster of paris partial cast, padded, running from mid-arm to about three inches above the wrist. A metal U bar is incorporated in the plaster at the region of the elbow, while from the distal end of the cast, another metal bar extends straight out beyond the hand defect. The bar at the elbow and the distal bar are attached to weights supported by a Balkan frame, giving fixed position and comfort.

dorsal defects. With free drainage established, the volar flaps went on to complete take. After these flaps were severed from

their base on the twenty-first day, the dorsals were relifted and immediately attached; these in turn went on to a complete healing.

The foot wounds, as was expected, presented the greatest problems. The cast application had to be meticulously performed to avoid tension of the pedicle. The wounded foot, due to vasomotor instability and the immobile flexed position of the knee in the fixation cast, exhibited mild degrees of congestion, which cleared in every case within a day or so. The greatest problem was the slow breaking down of the cast and the gradual pull of the pedicle, separating the edges of the flap from the wound defect. In two cases, the casts broke within two days, and had pulled the flaps about half way off the defects. These patients were reoperated upon, the flaps lifted, refreshed and reapplied with good results.

All attempts were made to decrease the size of the foot wounds. Some parts of the defects were superficial and could easily tolerate a free graft. In such cases, a thick, split skin free graft, .024 of an inch, was applied one week before the flap was attached. In three of such cases, the thigh flap was raised and resutured in a delaying



FIG. 11. Illustrates the foot fixation cast. The cast is a strongly braced spica from the hips to the foot and contains a window cut out to show the entire flap.

process at the same operation. One week later by the time the flap was sutured on, the split skin was firmly fixed and healing well. (Fig. 7.)

Functional Results. No patient was observed for more than 170 days after injury; most were either discharged to duty or evacuated within ninety days. Our results, therefore, had to be considered from a short time viewpoint.

A review of our Tables will reveal that thirty-four cases involved the hands; of these, eight had severe finger injuries. Where tendons or joints were exposed, the usual results were fingers with varying degrees of limited motion. For those patients with complete fixation of the joints, covering the wounds with a flap retained the fingers in the optimal function with prime consideration given to maintaining the grasp position.

Six cases had wounds of the first web space with partial loss of the adductor, lumbrical and interosseii muscles; we finished with excellent functional retention of prehension (opposition between thumb and finger) in all of these cases.

Three patients lost their thumbs; one had an exposed first metacarpal bone with granulating tissue instead of a web space. The latter was repaired by partially dis-

secting along the lumbrical and interosseii muscles, freeing the first metacarpal and creating a new web space by placing an abdominal flap in the sulcus; the functional result was good. No attempts were made to build new thumbs for two of our patients who lost their first metacarpals as well as the thumbs.

The flaps over the palm and dorsal hand defects resulted in healed wounds. However, in all of our cases, since tendons were completely destroyed, motion to the fingers supplied by those tendons was lost. Further tendon transplanting would have to be done at a later date.

The remainder of our hand patients having exposed bones showed good grasping functional results after the wounds were healed.

It was difficult to evaluate our feet cases, those who did not have much bony damage were able to walk with no trouble. The patients with loss of bony substance did complain of pain on standing. We have had no follow up on these cases after evacuation to America.

Early Physical Therapy. To ensure early function in hand wounds, a definite functional program was instituted. Since our regular physical therapy department was overburdened, a nurse experienced in

the problems of the plastic-maxillofacial service was assigned to full time care of all hand cases. The treatment concerned itself with passive movements of the fingers as well as constant encouragement in active motion. As soon as the patient was placed in his fixation position for the flap graft, the nurse would spend the necessary time to encourage the patient to use his uninjured but stiff fingers. Four days after the flap was severed from the pedicle and completely sutured over the defect, the patient was started on warm saline soakings, the nurse assisting in active and passive finger movements. (To measure progress, time permitting, goniometer readings were taken.) Individual elastic cuff apparatus were made to give continuous motion to the fingers. Made of plaster of paris, shipping carton baling bands and the cuffs of discarded surgical rubber gloves, this type of traction could be used for any joint by adjusting the lines of direction. The patient could play against the elastic traction and have forced active motion. (Fig. 13.) To start early skilled acts, the nurse would advise and direct the patients on all kinds of games which required the use of fingers.

SUMMARY

1. Forty-nine cases of flap graft closures were performed for deep wounds of the hands and feet, with good functional results.

2. The very early cover of exposed infected tendon and bone is advocated by the use of this technic.

3. The flap graft technic is quick and sure of take in covering wounds of the hands and feet with a fat-containing skin cover.

4. The principles of multiple blood transfusions and penicillin therapy are believed to be important adjuncts in the graft take.

5. Early physical therapy for optimal function is a full time job for a trained nurse or assistant who understands the problems.

The author wishes to thank Colonel George Dixon, Major Arthur Weinberg and Captain Benjamin Hoffman for their assistance and advice in this series of cases; Sergeants Schwone and Ryan for their tireless labors in doing dressings and making mechanical apparatuses.

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SPLINTS AND CASTS IN THE TREATMENT OF WAR INJURIES

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NO one will question that the availability and proper use of splints and casts in the treatment of war injuries are important factors affecting morbidity and mortality. It is also a fact that many of our doctors who in civil practice rarely or never had occasion to apply a splint became familiar with them in the course of their war experiences. What happened then as regards the use of casts and splints becomes understandable. The suddenly expanded medical corps had to learn the hard way, by trial and error. Mistakes occurred early in the game but with accumulating experience they were avoided, much was eliminated by directive and gradually a good deal of essential standardization crept in.

During the course of four war years in the army medical corps I worked at different times as surgeon in a Clearing Station, Field Hospital, Surgical Hospital, Evacuation Hospital and numbered and named General Hospitals. I soon learned that I had to adapt my civilian fracture experience to the peculiar exigencies of war surgery with its mass production methods, long chain of evacuation, segmented treatment and division of surgical responsibility. Methods of splinting and cast application which had proven valuable at home with one patient under the control of one doctor in one hospital throughout the period of treatment could not in most instances be used for wounded soldiers who were cared for by dozens of different doctors, who faced a long tedious journey which was pretty rough in spots and whose fractures, wounds and extremities were very easily lost sight of in the constant shuffle and change from one hospital to another.

Safety, simplicity and security were the

criteria by which proposed splints and casts were judged. It was a matter of the greatest good for the greatest number and a few methods which could be readily standardized and uniformly practiced had to be chosen, regardless of the training or preference of any one man.

Naturally the requirements in one theatre or portion of it differed from those in another and a good deal of flexibility in the approach to the problem had to be preserved. In view of this the subject of splints and casts in the treatment of war injuries can perhaps best be taken up under three general headings: Emergency Splinting, Transportation Splinting and Definitive Splinting, according to the particular echelon of command which is under consideration.

EMERGENCY SPLINTING (BATTALION AID STATION)

Here, right in the so-called "front lines," where the injury was sustained and the wounded man received his first medical aid, there existed, theoretically at least, the golden opportunity to prevent further shock and tissue damage by the intelligent splinting of a major wound. I say "theoretically" for unless one has actually served as a Battalion Aid man or worked closely with them he can not possibly comprehend the variety and extent of the obstacles and difficulties that have to be overcome. Such things as weather (wind, rain, snow, hail, fog, heat and cold) and terrain (mud, sand, rocks, bogs, woods, rivers and mountains) merely add to and complicate the mortal hazards of mines, booby traps, barbed wire, strafing, shell and small arms fire which Battalion Aid workers had to face. Then there were such tactical factors as rapid movements forward or back, communica-



FIG. 1. Improvised shoulder spica for compound badly comminuted elbow fracture. Patient ready for sixty mile evacuation from clearing station the morning after surgery. This illustrates an error in cast technic which was not uncommon in the early days of field operation. The forearm should have been much lower and closer to the body so as to avoid interference with an overhanging stretcher; Maktar, Tunisia, February, 1943.

tion, transportation and supply which were constantly changing.

It was one thing to find a wounded G.I. at night—for the largest part of this work had to be done under cover of darkness—and quite another to apply an adequate splint in the field and carry a 175 to 200 pound soldier back to our own lines. Now as a matter of fact regulation army halfring splints were usually available in the Battalion Aid Station. Our medical corps men were well trained and highly proficient in their application, and they used them whenever it was humanly possible to do so.

Of course, there were occasions when, due to extraordinary circumstances, regulation splints were not to be had in the field. In a number of instances clever improvisation by Battalion Aid men achieved effective splinting. The soldier's rifle was sometimes tied alongside his broken leg with his belt and strips torn from his clothing; or a broken arm was swathed to the body with his blouse. Sticks and boards were similarly pressed into service in

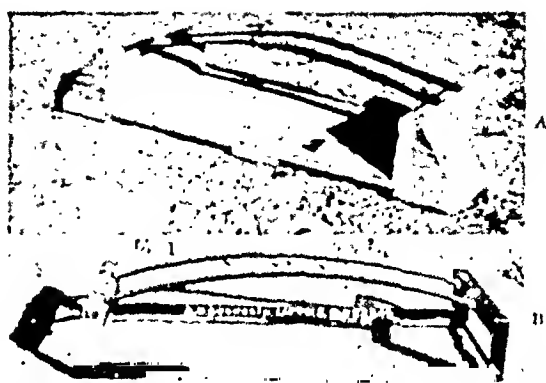


FIG. 2. A, Goldthwaite frame improvised in the field from crates and spring leaves of a jeep; Arzew, Algeria, November, 1942. B, streamlined version of same quickly welded by an ordnance outfit from scrap metal in the field; Feriana, Tunisia, April, 1943.

emergencies. These were recognized as purely stopgap and temporary expedients but they were preferable to no attempt at immobilization and they reflected credit on the stretcher bearers.

Plaster was not employed forward of Clearing Stations and Field Hospitals where the primary major surgery was done. Not only was it physically impracticable but it was believed that wounds should not be encased in plaster until they had been rendered surgically clean. So in World War II our regulation army halfring splint (successor to the Thomas splint) proved itself a God-send to men in the Battalion Aid and Collecting Stations. They had it, they knew how to apply it and they used it. There can be no doubt of the great number of lives and limbs which were preserved by this simple apparatus.

TRANSPORTATION SPLINTING (PRIMARY SURGICAL INSTALLATIONS)

In this war most of the primary surgery was done in Surgical, Field or Evacuation Hospitals and it was in these installations that more adequate methods of splinting had to be devised for purposes of transportation. Here was the first opportunity to employ a material which could readily be adapted and molded to the needs of the individual case. When the pressure was on, patients with fractures were operated

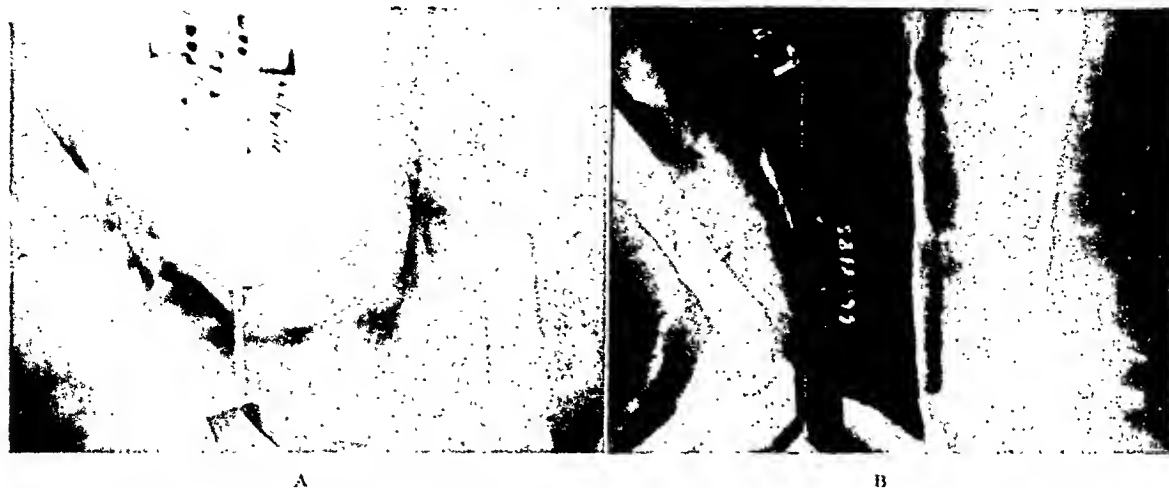


FIG. 3. A, simple fracture of lower third of humerus after three attempts at closed reduction and external splinting. B, same after open reduction and internal splinting in the Zone of Communication.

upon and evacuated within twenty-four to forty-eight hours and they were usually at a hospital in the Zone of Communication for more definitive treatment within an added three to five days. So the halfring splint was in most instances replaced after surgery by some simple form of plaster splint. As it was realized that his cast would usually be removed upon the patient's arrival at a hospital further back, it was not elaborated upon nor was valuable time lost in an attempt to secure anatomic reduction of a fracture.

Great attention, however, was paid to certain fundamental points. All casts were required to be well padded, especially over bony prominences such as tuberosities, condyles and malleoli. As has been previously stressed,¹ the unpadded cast technique, while efficient in certain skilled hands, has no place in field surgery. A corollary to this rule was the requirement that all circular casts and circular dressings about an extremity be split right down to the skin immediately after application. The importance of this simple precaution was attested by several extremities which came to amputation solely as a result of circulatory interference from swelling and edema beneath an unsplit circular dressing. A rough line drawing in indelible pencil on the cast outlining the fracture with a few pertinent notes as to times of injury and treatment, by whom treated and the presence of additional injuries was of great

value to physicians under whose care the patient subsequently came. X-rays and medical records were not infrequently lost or separated from the patient, and the added time taken to record on the cast itself the essential data mentioned was well spent.

Fractures of the humerus were usually immobilized in a shoulder spica with the arm down and forward across the chest so as not to obstruct the aisle of a crowded hospital train, plain or ship and not to bump against an overhanging bunk or stretcher. (Fig. 1.) Special apparatus and equipment was frequently lacking in these forward installations and shoulder spicas were commonly applied with the patient's back, shoulders and head supported on a broomstick placed longitudinally on the table or stretcher beneath his spine. A modified Goldwaite frame, however, could easily be improvised (Fig. 2) and it facilitated the procedure considerably. Exceptions had to be made when chest complications contraindicated the use of a shoulder spica. In such cases anteroposterior "elephant tusk" plaster splints were used. These extended the full length of arm and forearm and across the front and back of the chest. They were held in place with bandages, swathes or a modified Velpeau. The hanging cast and modifications of it, which were employed in fixed hospital installations in the rear, were used early in the war by field units but were later discarded

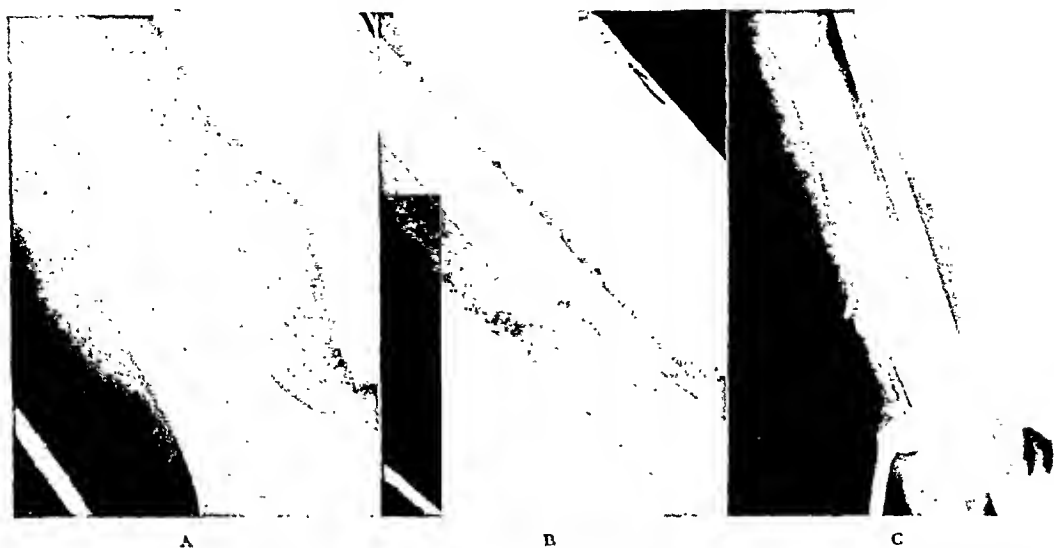


FIG. 4. A, half ring splint with wire traction for supracondylar fracture of femur. B and C, same, showing improved position as the result of pressure bandages applied in the half ring splint.

in favor of the shoulder spica as they provided insufficient immobilization during transportation and patients complained of pain and discomfort.

A simple circular cast below the elbow sufficed for most fractures of the radius or ulna; if both bones were broken, the cast was run up high on the arm which was then placed in a sling. Fractured carpals, metacarpals and phalanges were evacuated either in a simple cast or with basswood splint protection, although occasionally when work was not pressing a traction splint of one form or another was applied.

Pelvic fractures were encased in a double hip spica. Better immobilization was obtained by extending this cast from the lower chest all the way to the toes, with hips and knees in 10 to 15 degrees flexion. This made a heavy bulky cast but one in which the patient was safe and comfortable. Care was taken to window the abdomen and perineum widely to provide for possible distention and bedpan facility.

Conventional types of body casts were used for the transportation of spine injuries from forward installations. Due to the frequency of associated injuries of chest, abdomen and extremities, however, many compromises in the choice and form of splint had to be made.

In the North African campaign, due chiefly to British enthusiasm, considerable interest was evoked in the Tobruk splint for fractures of the femur and knee. Theoretically, this type of splint permitted more comfortable transportation than the hip spica for both the patient and his stretcher bearers. The patient could sit up and the cast was relatively light. Also, it did not protrude beyond the limits of the stretcher. Essentially this method consisted of traction in a halfring splint with a long posterior mold and a light plaster shell from toes to thigh.¹ However, after a reasonable trial by experienced personnel it was discarded in favor of a well applied spica. In my experience the spica provided far better immobilization of the fracture and greater comfort to the patient. One type of splint was about as easy (or hard) to apply as the other. The spica was kept low on the pelvis by tying in the well leg above the knee. A transverse wood strut was wrapped into the cast just above the knees. This braced the spica and was also of great use in lifting and turning the patient. It was placed on the back of the cast for greater solidity and did not interfere with the bedpan since it was well below the perineum.

Fractures of both bones of the leg were put in a circular toe-to-thigh cast with the knee in 10 to 15 degrees flexion and the

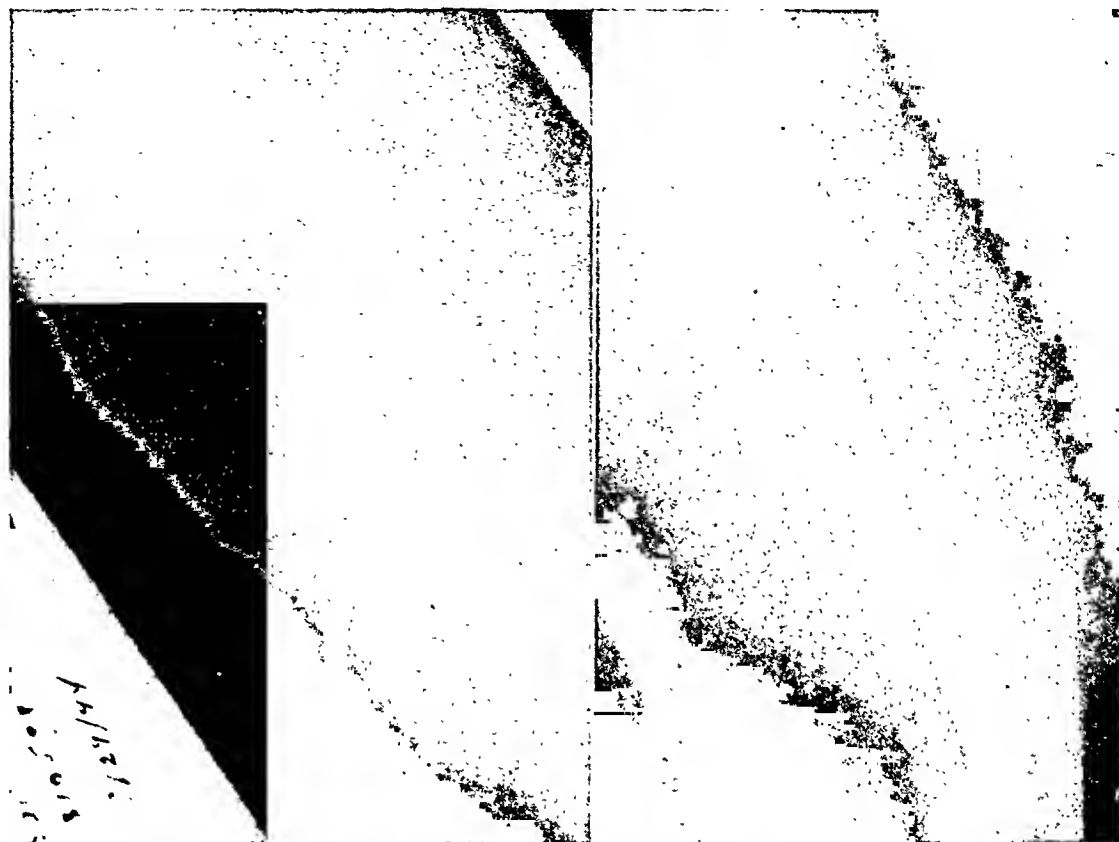


FIG. 5. This shows the inadequacy of a half ring splint in the definitive treatment of massive shattering fractures of the femoral shaft; a spica is preferable.

foot at 90 degrees. A below-the-knee cast sufficed for most single fractures of either tibia or fibula, for ankle and for foot fractures.

While the value of adequate splints in the transportation of fractures has been taken as a matter of course, their importance in the protection of massive soft tissue injuries of the extremities without bone damage was slow in attaining the general recognition that it deserved. Avulsion, laceration and destruction of large skin areas and muscle bundles occurred not infrequently. Posterior molds, sugar tongs and circular casts proved invaluable in putting these tissues at rest and protecting them from further insult during transit to the rear.

In the early days, following amputation in the field, muscle countertraction was maintained in a regulation halfring splint during evacuation. Later, a much more comfortable and effective method was adopted. The proximal portion of the stump, well away from the wound, was

encased in a temporary light circular plaster cuff with a wire ladder loop incorporated in it for muscle stabilization and elastic traction through a stockinette.

DEFINITIVE SPLINTING (ZONE OF COMMUNICATION AND ZONE OF INTERIOR)

In this are included the numbered General and Station Hospitals in the Zone of Communication and named General Hospitals in the Zone of the Interior.

Zone of Communication. For most patients the treatment in these installations was definitive and the methods of splinting used were in many respects those employed in civilian practice at home. Due to the fact, however, that there were such numbers of cases of any one common type of fracture, a certain amount of standardization and mass production in treatment methods was not only practicable but imperative. This again meant in large measure splinting by directive rather than by choice.

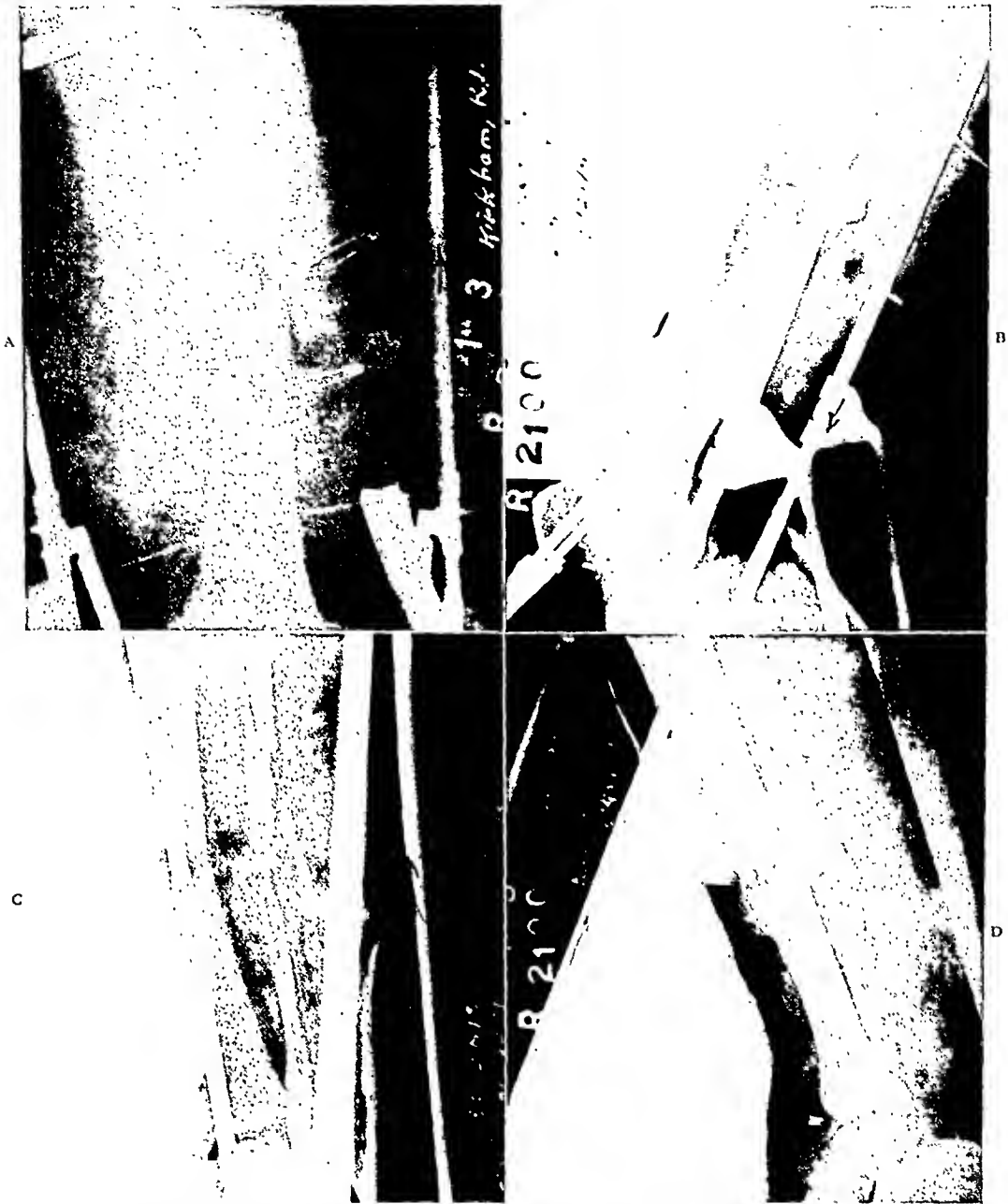


FIG. 6. A and B, half ring splint with Kirschner wire traction for fractured femur. C and D, circular cast used simultaneously for severe fractures of tibia and fibula in the same extremity.

The use of any form of internal splint (plates, screws, pins) was frowned upon and discouraged. I am satisfied that this was a good general rule, but I believe that it should have been more flexible and that exceptions could profitably have been made with greater frequency in individual cases in which the surgeon was well qualified and the facilities for postoperative care and rehabilitation adequate. It is doubtless

true that the results of internal splinting were not in many instances as happy as those obtained in civilian practice but few men experienced in traumatic surgery will question the advisability, for instance, of an open reduction and internal fixation of a simple fracture of the lower third of the humerus which is stuck in malposition and cannot be replaced by closed reduction. (Fig. 3.)



FIG. 7. A, combined use of circular cast and wire traction for shattered tibia and double fracture of fibula. B, it was possible to improve the alignment by wedging the cast while maintaining moderate traction.

P. T., aged twenty-one, a Field Artillery gunner, sustained a simple fracture of the lower third of the humerus in a jeep accident October 8, 1944. He was treated with a traction cast and three separate attempts were made to improve the position of the fragments by closed reduction under anesthesia. All were unsuccessful. Open reduction, correction of the deformity and internal fixation with a 4 screw Vitallium plate were done on November 11, 1944, in a numbered general hospital in the United Kingdom. At operation, as expected, the fragments were found to be united solidly with abundant callus which had to be removed before reduction was secured.

By having an internal splint applied in the Zone of Communication instead of the Zone of Interior, this lad was saved weeks or months of prolonged convalescence and rehabilitation and the army profited to that extent. Without correction and internal splinting he would have been a complete loss to the services as well as permanently handicapped. So there was, in my opinion, a real need of the internal splint in selected cases certainly as far forward as the Zone of Communication.

In general, good results were obtained in the Zone of Communication by treating fractured humeri with a hanging cast in which were incorporated tapes for suspension and traction or by Kirschner wire traction in a regulation halfring splint. After six to eight weeks the fracture was usually frozen sufficiently for removal of plaster and institution of physiotherapy or for evacuation of the patient in a shoulder spica to the Zone of the Interior.

In the definitive treatment of hand fractures in the Zone of Communication the results achieved seemed poorer than for any other common type of fracture. This was due principally, I believe, to two things: In the first place, the importance of function as opposed to anatomic reduction was not sufficiently understood and generally appreciated. Too much attention was paid to splints and too little to early motion regardless of some bone deformity visible on the x-ray. Secondly, all too often these injuries were regarded as minor matters and their treatment was delegated to the less experienced members of the staff.

These small fractures are not dramatic unless one makes them so in his own mind; it was all too easy to apply a cast or a splint and forget about them for a period of weeks. Towards the end of the war, however, when poor results began to collect in impressive numbers, a real effort was made to institute more functional methods of treatment and to make hospital staffs more finger conscious. Splints were then used very sparingly and sometimes not at all.

In the treatment of fractured femora and knees the regulation army halfring splint with Kirschner wire traction was widely employed. Traction was thus maintained until the formation of sufficient callus to permit evacuation of the patient in a double hip spica to the Zone of Interior. This method of splinting permitted the use of accessory measures such as countertraction and pressure bandages to improve alignment and position. (Fig. 4.) It also aided in preserving the function of neighboring joints during the prolonged period of treatment. In some instances, however, comminution of the bone was so severe and extensive (Fig. 5) or the condition of the soft tissues was such that encasement in a plaster spica was mandatory.

Severe fractures of femur, tibia and fibula in the same extremity posed difficult and not infrequent problems. Encasement of the leg in plaster and the application of Kirschner wire traction on the femur in a halfring splint provided a satisfactory solution in some cases. (Fig. 6.)

Ordinarily, fractures of both bones of the leg were treated with Kirschner wire traction in a halfring splint or were immobilized in a toe-to-thigh cast. Occasionally, a combination of the two methods, permitting maintenance of traction and

wedging of the cast to improve alignment, was employed. (Fig. 7.)

Zone of the Interior. In the named General Hospitals at home methods of splinting closely approximated those of civilian practice and therefore need no elaboration here. As would be expected, internal splints were more freely employed. By the time the patient arrived in the United States his physical condition, local and general, was often well stabilized and his morale improved. Facilities for treatment and after-care were in some respects more adequate and better organized, and certainly not least in importance was minimization of the time element as an essential factor affecting the type of treatment chosen.

SUMMARY

The use of splints and casts in the treatment of war injuries varied according to the particular echelon of command in which they were required. In general, emergency splinting was effected with the regulation army halfring splint. For transportation following primary surgery plaster was almost universally employed. Definitive splinting in the Zone of Communication was accomplished by use of the halfring splint or plaster, frequently by a combination of the two. Internal splinting was, for the most part, reserved for the Zone of the Interior. Two points deserve especial attention; the use of splints in the protection of extensive soft tissue injuries during transportation and the abuse of splints in the treatment of fractures of the hand.

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FRACTURES OF THE UPPER EXTREMITY*

A REVIEW OF EXPERIENCES IN WORLD WAR II

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THE tremendous number of fractures, simple as well as compound, which occur during war, provides an unusual opportunity for comparing the applicability, safety and reliability of different methods of fracture treatment. Although the treatment of fractures under battle conditions on land and on shipboard must of necessity differ from treatment in ordinary life, the basic principles of management apply to both types, and lessons learned during World War II should prove of great value during the years of peace.

Experiences in this war have re-emphasized the importance of mobility as the predominant requirement for the upper extremity in contrast to stability for the lower. Proper joint function should be the objective even at the expense of shortening of the bone. All joints of the upper extremity are closely related and the motion of all must be subservient to the proper functioning of the hand.

Coincident with the development of early ambulation following surgery in civilian life, an intensive reconditioning program for the sick and wounded with the patient as his own physiotherapist was instituted in the Army. Ambulatory treatment was greatly stressed under this program and was particularly applicable to patients with fractures of the upper extremity, who were treated in this way whenever possible.

The war has also afforded a testing ground for new technics in the treatment of upper extremity fractures. Experience has proved the efficiency of the "hanging cast" in treating most humeral fractures, has emphasized the necessity of splinting

fractures of the hand in the position of function, and by providing an unexpectedly large number of carpal scaphoid fractures has crystallized opinion concerning the management of this injury.

THE PROBLEM OF COMPOUND BATTLE FRACTURES OF THE UPPER EXTREMITY

Compound fractures sustained in battle, unlike simple fractures, differ greatly from those in civilian life; they show greater comminution, more extensive soft tissue wounds with a higher percentage of retained clothing and foreign bodies, and their treatment is often complicated by the necessity for evacuation over long distances. These differences have given rise to a policy, advocated by almost all army and navy surgeons, of leaving wounds open following primary surgery.

During the first years of the war the majority of compound fractures were treated by the "closed plaster" technic used by Trueta in the Spanish Civil War.¹ His program stressed prompt surgical treatment, cleansing of the wound, a thorough débridement, provision for drainage and immobilization in plaster until healing occurred. The method was enthusiastically endorsed by many surgeons. It was found especially useful when traction methods requiring weights and pulleys could not be used, as on shipboard.^{2,3,4} At the beginning of the war Kirk⁵ questioned whether it was possible to maintain reduction of fractures of the shafts of long bones by this method unless the fracture was transverse. The doubt was well justified; fractures of the femur and many fractures

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of the tibia were shown to require traction methods.^{6,7,8}

Fractures of the upper extremity, however, were better suited to the closed plaster technic. By using a hanging cast the advantages of both traction and "closed plaster" were utilized.^{9,10} Fractures of the radius and ulna could usually be maintained in position by plaster alone or by the insertion of pins incorporated in plaster.^{11,12,13} Although position and alignment of bone might be maintained by "closed plaster," in many fractures of the upper extremity soft tissue deformity was great. The introduction of reparative surgery by Churchill,¹⁴ in which the wounds were closed by delayed primary suture within ten days after injury, converted a compound fracture into a simple fracture, minimized scarring and saved many hospital days. Many reports confirmed the value of this program. MacFarlane¹⁵ recorded seventy-four cases of compound fractures of the upper extremity closed on an average of 7.6 days following primary surgery with success in 90 per cent. Kergin¹⁶ stated in 1945 that early wound closure was the most significant advance in surgery in this war. The importance of thorough débridement as an essential feature of both the closed plaster technic and delayed primary suture cannot be overemphasized. The new chemotherapeutic agents were an important part of this program although their exact value has not been determined.

Internal skeletal fixation for the treatment of compound fractures was used very rarely in this war. Experience showed that more conservative methods were preferable under battle conditions.¹⁷ Hampton¹⁸ reported its use in 332 selected cases, but only ninety-eight of these were fractures of the upper extremity and only in the exceptional case is this method required. In the restoration of the articular surface of a major joint internal skeletal fixation is often indicated.

External skeletal fixation in the treatment of fractures in the armed forces has been advocated by Shaar,^{19,20} who reported

the successful use of the Stader splint in 110 consecutive cases of acute fracture treated at the Naval Hospital in Philadelphia. Thirty-one of these were fractures of the upper extremity. Bradford and Wilson,²¹ reporting on the use of the Roger Anderson and Haynes apparatus in the American Hospital in Britain, found that this technic was rarely indicated for bones of the upper extremity. External skeletal fixation was not found useful under battle conditions;^{3,17} it was time consuming, not applicable to large numbers of casualties and was reported to give a high incidence of infection about the pin sites.

Compound battle fractures are often complicated by nerve and arterial damage which greatly influences the treatment; such injuries are especially common in upper extremity fractures. Nerve injury was found in 40 per cent of a series of gunshot fractures of the humeral shaft, radial in 33 per cent and median in 7 per cent.¹⁰ Treatment of the nerve injury often assumes first importance. The early repair of nerves is essential for good results; patients should be transported to neurosurgical centers as soon as possible for specialized surgery. Overzealous splinting of the wrist and fingers in extension for radial nerve injuries may result in fixation in that position.

Circulatory impairment was due not only to damaged major vessels but also to constriction by tight plaster casts, to tamponade of circulation from unsuspected hemorrhage beneath the deep fascia²² and to vasospasm.²³ Splitting plaster casts through their entire length was necessary for the prevention of constriction in recent injuries.^{24,25} Where hemorrhage was present, it was necessary to split the deep fascia in order to release tension and control bleeding. Vasospasm was treated by procaine hydrochloride blocks of the regional sympathetic ganglia.²³ By employment of these methods gangrene or ischemic paralysis was often prevented.

In the treatment of compound fractures of the upper extremity complicated by a

burn, Warthen²⁶ advised a compression dressing covered by a circular plaster cast.

TEMPORARY IMMOBILIZATION OF FRACTURES OF THE UPPER EXTREMITY

In contrast to fractures of the lower extremity, upper extremity fractures were easy to immobilize for evacuation to fixed installations. Most patients with fractures of the humerus, both simple and compound, were adequately transported with the arm near the side.^{2,4,10,27,28} This could be accomplished by a circular plaster cast from axilla to wrist fixed to the body by encircling bandages, which could later be converted into a hanging cast by removal of the bandages; or it could be accomplished by a chest pad with a double sling, by a Velpeau type bandage or by a plaster spica with only slight abduction.

It was shown definitely that the hinged arm traction splint (Murray-Jones); advocated at the beginning of the war, should not be used because of the danger of nerve and blood vessel injury from pressure in the axilla.²⁸ Fractures involving the shoulder joint required a spica. When a spica is used only mild abduction is required. Wide abduction often produces medial angulation and is cumbersome for transportation on airplanes and ships.^{4,10,27} Fractures of the elbow are best immobilized at right angles in plaster; and fractures of the forearm by circular plaster including elbow and wrist, or by plaster "sugar tongs."²⁸

A study of hand cases evacuated from the South Pacific²⁴ showed that when immobilizing any portion of the upper extremity it is of the greatest importance to immobilize the fingers only when absolutely necessary and then in the semi-flexed position. Casts used to immobilize the wrist should extend only to the distal palmar crease in the palm, leaving the fingers absolutely free, and should extend to just back of the knuckles on the dorsum in order to prevent edema. Immobilization of the wrist and forearm is mandatory in lesions of the hand. If it is necessary to immobilize

the thumb, a position of opposition should be used.

PROBLEMS RELATED TO SPECIFIC BONES

Clavicle. No universally applicable method of treatment has been found for fractures of the clavicle and many different forms of therapy were used during the war. Although non-union of the clavicle is very rare, the accurate reduction of fractures of the clavicle was important in military surgery because minor deformities of this bone cause pain to men wearing a pack or gun.²⁹ The plaster figure-of-eight splint was widely used. Packer³⁰ reported the use of a plaster jacket for the treatment of fractures of the clavicle. It extended down to the lower ribs, and was closely applied to the root of the neck and well out to the deltoids. It was trimmed from under the armpits to allow the limbs to hang normally without circulatory embarrassment. The weight of the cast was carried on the proximal fragment rather than on the shoulder by means of a thick pressure pad. The author stated that the soldier was able to wear normal clothing over this dressing and could return to duty in a few days. Immobilization was carried out for four to six weeks. Intramedullary pinning for fractures of the clavicle, introduced by Gordon Murray,³¹ was evidently not considered necessary in most cases as judged by the paucity of reports of its use in military service.

Compound fractures of the clavicle were well handled by a plaster shoulder spica which did not need to include the elbow. If the shoulder joint is involved, the arm should be abducted 60 degrees and held about 45 degrees forward to the plane of the body.

Humerus. Almost all fractures of the humerus, including those of the upper third, were best treated with the arm near the side; wide abduction was often harmful because it caused considerable medial angulation of the fragments.^{6,10,27} The efficiency of the hanging plaster cast for treating fractures of the humerus was amply dem-

onstrated in the services.^{2,6,9,10,11,12,13,22,29} Its limitations and dangers were also forcibly brought out. Because traction of the cast may result in overpull, frequent x-ray examination must be made during the early part of treatment. While reduction may be accomplished by the use of the cast alone in many cases, the hanging cast should not be depended on for reduction; and unless x-rays show a satisfactory position within a few days, further treatment is necessary. All authors emphasized the importance of early shoulder exercises when the hanging cast was used.

Compound fractures as well as simple were adequately managed by the hanging plaster cast, which proved to be the simplest and most efficient method of handling these injuries in the combat zone. In cases of bone loss, however, the plaster spica should be used to prevent distraction.

Compound fractures of the humerus are associated with a high incidence of nerve and blood vessel damage, which must be carefully treated along with the fracture. When circulatory damage is present, plaster casts should not be applied until the danger of ischemia is past.²³ Radial nerve damage is extremely common. It is important when splinting the wrist and fingers in radial nerve injuries to make the splints removable so that the fingers and wrist can be moved throughout a full range of motion several times daily. If this is not done, considerable joint stiffness may result.

Reports from civilian surgeons during the war have emphasized the value of early mobilization in the treatment of fractures of the upper end of the humerus in preventing stiffness of the shoulder joint.³²⁻³⁶ Although this is of greater importance in the older age groups than in those of military age, early mobilization should always be used in such fractures when practicable. If there is no displacement, it is sufficient to treat the fracture by an axillary pad with the arm fixed to the side of the body, the elbow free and the wrist supported by a cuff suspended from the neck. In fractures of the upper end of the humerus

which are difficult to reduce by manipulation and traction the short upper fragment is usually abducted and rotated outward, while the pectoralis major and subscapularis tend to draw the proximal end of the distal fragment inward and upward. In such fractures open reduction may be required. Key³³ fixed the fragments after reduction with two Kirschner wires, leaving one inch of each protruding from the skin to be removed later. In severe fracture dislocations which can not be reduced by closed methods, internal skeletal fixation is required.

Although ambulatory methods of treating fractures of the humerus were always preferable, bed treatment was sometimes required because of associated injuries, and this often necessitated traction methods. Webster,³⁷ of the Navy, described an apparatus for securing lateral traction in the upper extremity which could be easily assembled and applied in both Army and Navy installations. Either skin or skeletal traction could be used. Traction may be applied to a hanging plaster cast, when it is necessary for the patients to remain in bed, by means of weights suspended over a pulley and attached to a loop incorporated in the plaster at the elbow.

The value of pronation of the forearm in correcting the varus deformity often associated with fractures of the lower end of the humeral shaft was emphasized by Kelly and Riley.³⁵ They showed in experimental fractures that pronation of the forearm relaxed the spasm of the powerful pronators attached to the medial condyle and responsible for lateral angulation if the forearm is supinated. Fractures of the lower end of the humeral shaft should be immobilized with the forearm in pronation. This position should be maintained, however, only until callus is firm enough to prevent displacement. Then the midposition should be assumed in order to reduce elbow stiffness. A careful analysis of a group of these injuries in the R.A.F. emphasized the importance of an organized rehabilitation program in overcoming elbow stiffness following humeral fractures.³⁹

An interesting and refreshing article concerning fractures of the humerus was reported in the *St. Bartholomew Hospital Journal* entitled "The Place of Organized Elbow Lifting in Treatment of the Fractured Humerus."⁴¹ The patient was a British squadron leader with a complete detachment of the greater tuberosity. Active motion of the elbow was begun under water on the fourth day. Starting on the ninth day the patient was forced to use the injured arm to raise all beverages to his mouth. The times of treatment corresponded to the exact time of the opening of the bar. Half pints only were used during the first few days but these were increased. Progress was astounding. The patient got his arm as high as the shoulder by the eleventh day and was discharged to ground duty in two weeks.

Elbow. Shands²⁹ stated that conservatism was advisable for military surgeons treating extensive comminuted and displaced fractures of the elbow since conservative methods give the greatest number of good results in the hands of the largest number of surgeons. He advocated open reduction with internal skeletal fixation only for the displaced single condyle which could not be held in proper alignment by simple methods, and for certain olecranon fractures. Before resorting to open reduction, skeletal traction should be tried with a Kirschner wire through the proximal ulna just distal to the tip of the olecranon. In fractures of the capitellum with a large fragment, reduction may be possible by direct pressure while the forearm is pronated, adducted and flexed slightly. If reduction is impossible, the fragment should be exposed by arthrotomy and either fixed by screws or removed.

Because compound fractures of the elbow joint often result in ankylosis, Devine⁴¹ advised immobilization in the position best suited to the occupation of the patient. Mobility of the elbow is much more important than stability, however, and everything possible should be done to gain some elbow motion, however slight. Forceful

manipulation of stiff elbows is rarely successful. A better final result was usually obtained with a program of continued, persistent and painstaking active motion.

The development of ischemic paralysis was encountered all too frequently in fractures about the elbow.¹⁰ In some instances it was due to tight, unsplit plaster casts. Incisions through the deep fascia, with the release of tense collections, was helpful in some cases. When traumatic vasospasm was present, procaine hydrochloride block of the stellate ganglion was effective in improving circulation.

Head of the Radius. Fractures of the head of the radius were exceedingly common in military service and frequently resulted in traumatic arthritis with limited painful motion.^{29, 42-47} There has been considerable controversy as to whether treatment by immobilization or by excision of the head is preferable. Because both methods left much to be desired Mason and Shutkin⁴³ tried immediate active motion associated with local heat with good immediate results. By starting early active motion it was hoped that small uncontrollable fragments of the head would be moved across the fixed uninjured surface of the humerus and would attain the best functional position. Only fractures with little displacement were treated by this method. Postlethwait⁴⁶ also tried the immediate active motion treatment in a small number of radial head fractures without displacement and reported encouraging results.

Most writers advised operation with excision of the head for fractures with displacement, although radial deviation of the wrist, lateral instability of the elbow, and excessive calcification about the elbow joint may complicate the operation in some instances. In an analysis of 110 radial head fractures in the R.A.F., Meekison⁴⁵ found that of thirty-two not operated on only three regained complete movement; in seventy-eight patients operated on good motion was regained in almost all. If excision is performed, it must be done early, preferably on the day of fracture, before

damage to the capitellar articular surface has resulted. At operation the injury is usually found to be more extensive than was anticipated. Old untreated fractures present a much more difficult problem because of the organized transudate within the capsule, and poor results were obtained by all methods.

Olecranon. Although some fractures of the olecranon with separation may be successfully treated by keeping the arm in complete extension, the danger of fixation of the elbow in this position often requires open reduction and internal skeletal fixation, either by absorbable or non-absorbable material.⁴⁷ When there is comminution of the articular portion, arthrotomy is indicated to remove the small articular fragments. Shands²⁹ warned against the removal of too many fragments or the complete excision of the olecranon process. Civilian surgeons^{48, 49, 50} reported the use of longitudinal pin and screw fixation for the treatment of these fractures, using materials of sufficient length to engage the cortex of the distal fragment. The following advantages were given: better reduction, better retention and shorter disability with early recovery of motion.

Monteggia's Fracture. Full function following the Monteggia fracture is rare. The common type is a fracture of the ulna about three to four inches below the tip of the olecranon associated with anterior dislocation of the head of the radius. Early reduction by closed methods may be successful. If not, open reduction with plating of the ulnar fracture is necessary. The elbow should be immobilized in a position of flexion with the forearm in supination. Suture of the orbicular ligament and the construction of fascial slings, which may be necessary in old cases to hold the dislocated head in place, is a procedure to be done only by the specialist.²⁹

Radius and Ulna. Because fractures of both bones of the forearm are technically very difficult to reduce and maintain in good position and because fractures of the middle third of the radius not uncommonly

result in non-union, fractures of the forearm presented an important problem to the military surgeon.^{47, 51, 52} The radius is usually displaced towards the ulna because the muscles on the radial side are stronger. It should be remembered that the ulna is important in movement and stability of the elbow, while the radius supports the hand, and that in rotary movements the ulna is fixed while the radius moves.

In fractures of the radius proximal to the insertion of the pronator radii teres the proximal fragment is supinated by the unopposed action of the biceps and supinator; these fractures should always be reduced and immobilized with the forearm in full supination. In fractures below the insertion of the pronator radii teres the pronators balance the supinators and the upper fragment is held in midposition; these injuries must be immobilized with the forearm in the midposition.

In oblique fractures of either one or both bones, shortening is frequent during immobilization in plaster. When both bones are fractured, shortening of the radius with ulnar angulation is the usual deformity. In these injuries some form of skeletal fixation is usually necessary. A good method, and one frequently used, was the insertion of one pin or wire through the proximal ulna and one through either the distal radius and ulna or the metacarpals with incorporation in plaster. This method was especially useful in treating compound fractures of both bones of the forearm if they could not be held by plaster alone.

When treating forearm fractures one should keep in mind the principle that all upper extremity therapy is directed chiefly toward the proper functioning of the hand. Compound fractures of the forearm may be especially destructive because so many structures—nerves, tendons, blood vessels—vital to the functioning of the hand are packed into a small space and may be injured. Causalgia is a frequent complication. Overzealous treatment of the fracture to the exclusion of other injuries may lead to a stiff and crippled hand.

Several authors⁵³⁻⁵⁴ commented on the infrequency of fractures of the lower end of the radius in the military service. Many so-called Colles fractures were above the Colles level. Joldersma⁵⁷ pointed out the usefulness of prolonged traction as advocated by Böhler in the reduction of fractures about the wrist. He used fixed traction with Chinese finger traps and a 15 pound pull for fifteen minutes. By this method he was able to reduce accurately almost all injuries in this region. The Cotton-Loder position of flexion and ulnar deviation may result in considerable stiffness. If this position is necessary for a time to hold the fragments in place, it should be changed to a neutral position as soon as the fragments are stabilized. Immobilization by moulded plaster splints should be carried out for three to five weeks. Opinions were divided as to the best anesthesia; some favored local, and some general.

Carpus. Fractures of the carpal scaphoid proved to be a tremendous problem in the armed forces. A much larger number of cases was encountered than had been anticipated, and because treatment was necessarily long and because most of these patients could not be treated while on a duty status, an enormous amount of time was lost. For these reasons and because this fracture lends itself well to analysis, there were more reports of carpal scaphoid fractures in World War II than of any other fracture of the upper extremity.^{45,53-56,58-65} In this respect fracture of the carpal scaphoid was the "march fracture" of the upper extremity. It was encountered much more frequently in the service than Colles fracture. During two years service in the Canadian Army McKim⁵⁶ encountered 125 scaphoid fractures and only eight Colles fractures. In a series of 110 fractures of the wrist Shands found 80 per cent to be fractures of the scaphoid, and Obletz⁵³ reports approximately the same incidence. This high frequency was attributed to the age and sex of members of the armed forces; fractures of the carpal scaphoid are found almost exclusively in vigorous young males,

and only rarely in the old and almost never in women. It is thought that the strong forearm and wrist muscles of young males resist hyperextension and project leverage more distally, causing a fracture of the scaphoid rather than a Colles fracture.^{45,53}

Most of the fractures occur through the midportion or waist of the scaphoid. Of 257 cases in the Canadian Army reported by Dickinson and Shannon⁶⁴ it was found that 75 per cent were through the waist, 15 per cent were through the proximal pole (proximal one-third of the bone), and only 10 per cent involved the tubercle. These authors expressed the opinion that the degree of radial deviation of the wrist at time of injury determines the segment of bone fractured; the more radially the wrist is deviated the more distally the bone is fractured.

Although union is slow, good results can be obtained if the diagnosis is made early and the proper treatment instituted. Diagnosis is easy for one who is familiar with the injury. There is the history of a fall, pain on motion of the wrist, tenderness and swelling over the navicular in the "snuff-box" area, increase of pain on passive motion of the thumb, and pain on percussion of the tip of the thumb. Diagnosis is confirmed by x-rays which, besides routine views, must include oblique views and anteroposterior views with the wrist in ulnar deviation. If these supplementary views are not taken, many scaphoid fractures will be missed on the first x-ray. Even with these views some fractures do not appear on the films for two or three weeks. If the clinical examination indicates that a fracture is present and the first x-ray is negative, the injury should be treated as a fracture for three weeks and another x-ray taken. A negative x-ray after three weeks is proof that no fracture exists.

Most writers have expressed the opinion that the treatment of recent fractures of the body of the scaphoid has been solved; it depends on prompt diagnosis and early institution of prolonged immobilization in the proper position. McKim⁵⁶ reported a

series of 125 scaphoid fractures so treated without a single case of non-union, and Dickinson and Shannon⁶⁴ reported 116 cases of fractures of the waist treated in like manner without a non-union. Tubercle fractures almost always heal within three to four weeks by simple immobilization of the wrist. But proximal pole fractures, because of the poor blood supply, occasionally result in non-union even if immobilized early. These fractures, fortunately, are rare.

The generally accepted treatment for fracture through the body of the scaphoid is that recommended by Soto-Hall.⁶⁵ The wrist is immobilized by a plaster cast in about 20 degrees dorsiflexion and full radial deviation with the thumb carried into full abduction. The plaster extends from just distal to the elbow to the middle of the thumb nail and to the distal crease in the palm. Immobilization must be continued until bony union occurs, a period averaging about three months.

While the treatment of fresh fractures of the scaphoid was generally agreed upon, there was controversy concerning the treatment of delayed union and non-union. Delayed union and non-union are usually due to avascularity and necrosis of the proximal pole. Oblatz⁶⁸ stated that avascularity is often temporary and that union will occur if prolonged immobilization is carried out. In cases showing improvement by x-ray, prolonged immobilization—sometimes as long as twelve to sixteen months—is recommended. Others^{68,69,70} do not concur in this belief, but advise surgery if union has not taken place in four or five months. Drilling of the ends of the fragments, bone grafting procedures and excision of the proximal fragment or the entire scaphoid have been recommended with special indications for each.

Soto-Hall⁶⁵ reported luxation of the lunate in 12 per cent of scaphoid fractures. If reduction is possible, the wrist should be immobilized in slight volar-flexion for four weeks. If reduction cannot be accomplished by closed means, the lunate must be excised.

Metacarpus and Phalanges. As stated by Mason,⁶⁶ "Nature has developed in the hand a finely coordinated motor and sensory organ which has made possible our present civilization." The importance of making all other motions of the upper extremity subservient to the proper functioning of the hand has been amply demonstrated during World War II. In injuries of the upper extremity the fingers should be immobilized only when absolutely necessary in order to avoid permanent stiffness. Casts which are applied for immobilization of the wrists should extend only to the distal palmar crease so that full finger motion may be maintained. In immobilizing hand injuries the concavity of the palm must be preserved, avoiding "flat" splinting.⁶⁷

Metacarpal fractures are usually just proximal to the head and, if displaced, result in dorsal angulation and recession of the metacarpal head into the palm. The spasm of the interosseous muscles, which is unopposed, maintains the flexed position of the distal fragment. In reduction it is necessary to flex the metacarpophalangeal joint to 90 degrees, which eliminates the interosseous spasm. Splinting the fingers in extension or the entire hand about a roll of bandage must be avoided if deformities are to be prevented. Splinting in extension results in a high incidence of contracture of the joint capsule.

Fractures in which reduction cannot be maintained by ordinary splinting require more radical therapy. Skeletal traction applied to the finger of the involved metacarpal was extensively used for these injuries.⁶⁸⁻⁷¹ Various materials were used to transfix the bone: towel clips,⁶⁹ small Kirschner wires,⁷⁰ and intravenous needles.^{68,71,72} Traction was usually obtained by means of rubber bands attached to wire loops incorporated in plaster with the finger in a position of flexion. The remaining fingers were left free.

The use of Kirschner wires drilled transversely through the involved metacarpal and into adjacent metacarpals for fixation

following reduction has been reported.^{73,74} This method was advocated for the four inner metacarpals only. Single wires were used for fractures through the neck or base and double wires for oblique fractures of the shaft. The hand and projecting portion of the wires were immobilized by a plaster cast which left the fingers free. Active mobilization of the fingers was begun at once and the patient sent to duty in a day or two.

More recently medullary canal wire transfixion was introduced for metacarpal fractures.⁷⁵ A short incision is made over the fracture site and a very fine Kirschner wire is inserted into the medullary cavity of the distal fragment, passed through the metacarpal head and through the overlying skin. The fragments are held in alignment while the course of the wire is reversed to the base of the metacarpal. The wire is held in place for two weeks and is removed by a simple skin incision. No external form of immobilization is used. This method has been employed extensively in army orthopedic centers for fixing iliac bone grafts used in treatment of non-union of the metacarpals.

Gunshot fractures of the metacarpals were serious because of frequent tendon and nerve damage and severe shattering of bone with loss of bone substance.^{67,76} In many cases skeletal traction is required for the reduction and maintenance of the fracture. Vasospasm is frequent and should be treated by stellate ganglion block with procaine hydrochloride.

Fractures of the phalanges, both simple and compound, were often very difficult to treat.⁷⁷ It is even more essential to obtain accurate reduction here than in fractures of the metacarpals. The interphalangeal joints more than any other joints in the upper extremity show a tendency to become fixed after continuous immobilization. Fractures of the proximal phalanx usually result in volar angulation because the interossei pull the proximal fragment into flexion. When reduction cannot be maintained by simple splinting, skeletal

traction with the metacarpophalangeal and proximal interphalangeal joints in flexion is required. The healthy fingers must be left free and active motion instituted from the first. In the débridement of compound fractures of the phalanges it is extremely important that all viable tissue be retained.

One of the greatest medical contributions of the war has been the work of Dr. Sterling Bunnell, who acted as civilian consultant to the Army on surgery of the hand. Dr. Bunnell's leadership has greatly stimulated military surgeons and his advice has been of untold value in the reconstruction of many crippled hands of the wounded.

SUMMARY

1. Fractures of the upper extremity in World War II were treated by ambulatory methods.

2. War experience has emphasized that the function of the joints of the upper extremity should be subservient to the proper functioning of the hand.

3. Fractures of the humerus were best handled with the arm near the body; the efficiency of the "hanging cast" was established.

4. A high incidence of carpal scaphoid fractures was encountered; good results were obtained by prolonged immobilization if instituted early.

5. Fingers immobilized in extension showed a high incidence of stiffness; positions of flexion should be used, and the uninjured fingers must not be immobilized.

6. Nerve and blood vessel injuries were frequent in compound fractures of the upper extremity, and these injuries often take precedence over treatment of the fracture.

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REHABILITATION OF THE SURGICAL PATIENT IN ARMY HOSPITALS IN WORLD WAR II

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AMONG the interesting developments of surgery of the recent war and evident as of interest in prior wars was the importance of developing as part of medical treatment a planned program of convalescent reconditioning. The forgotten surgical patient in civil practice is he who has been discharged from the hospital to the home care of relatives for the convalescent period. The Surgeon General in 1943 fully appreciated the problem relative to the soldier patient, who, when discharged from the hospital must be physically fit to report for a full day's military duty or discharged to civil status fit to assume the full responsibilities of independent economic life.

Every surgeon is conscious of the deleterious effect of prolonged bed rest in his surgical patients. At the present time there is a great interest in the early ambulation of patients in civilian hospitals. Perhaps no more provocative discussion has been published in medical literature of the past half century. However, recent articles by Powers¹ and Elman² lead the interest of the reader forward. The current situation in civilian hospitals, where nurse shortages have forced a policy of bed scarcities and rapid turnover of patients, has compelled surgeons to shorten the period of hospital stay and to utilize approved methods of accomplishing early ambulation and reconditioning.

History bears out the fact that in each great war there has been a surge of interest in the convalescent care of military patients necessitated by the critical shortages of personnel. In fact, the salvage of manpower both military and industrial has been the motivating power in each war, perhaps

never before so much so as in World War II. With a good program of convalescent reconditioning, many patients have been returned to full military duty that otherwise would only have been capable of performing limited duty; and, furthermore, large numbers have been salvaged for limited duty that otherwise would have been discharged to civil life. In the recent war 58.8 per cent³ of the wounded were returned to military duty within the overseas theaters—an important number of military personnel too have been salvaged. The best results have been reported from the Convalescent Centers of the European Theater where 84.5 per cent of the patients were returned to duty within the theater.

Perhaps the size of the problems facing the medical department in accomplishing its mission of preserving the military strength of the Army would be more clearly demonstrated by the following tabulation:

TABLE I
BATTLE CASUALTIES¹

Wounded	Missing	Prisoners	Killed	Total Casualties*
570,783	56,867	114,205	201,367	943,222

* Figures inclusive of June 30, 1945, only.

Two factors are responsible for these results, (1) the superior quality of surgery in Army Hospitals and in the field and (2) a well organized reconditioning program, operating within each Theater of Operations and in the Zone of Interior.

The convalescent reconditioning program in Army Service Force hospitals was originally conceived of primarily for the preservation of the fighting strength of the

* Reconditioning Consultants Division, Office of The Surgeon General, U. S. Army—on terminal leave.

Army. It was conceived for adaptation to the surgical patient and it was developed in three aspects, (1) physical reconditioning, (2) educational reconditioning and (3) occupational therapy (operating in close cooperation with physical therapy). It seems appropriate to describe in this paper the physical reconditioning aspect primarily.

Patients were classified into four groups—each having its own program of activities adapted to the physical and mental limitations of each group, as follows: *Class 4*—bed and chair patients; *Class 3*—ward ambulant patients; *Class 2* and *1*—progressively free ambulant patients.

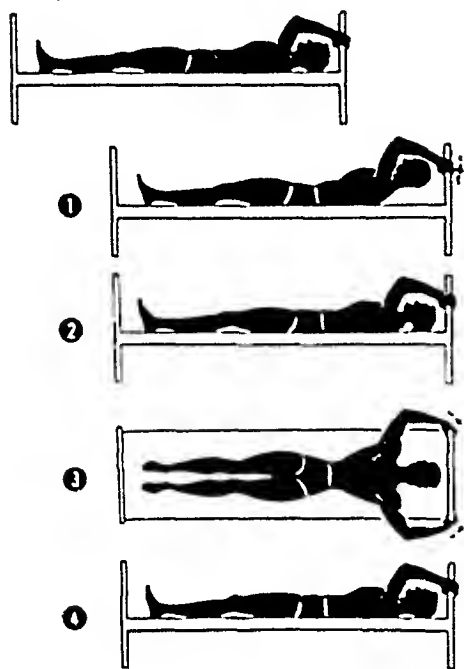
Even the afebrile surgical patient in leg traction profited from a physical and mental exercise program and from functional occupational therapy if those parts of his body not injured were exercised. Moreover, the program began early in convalescence. Specific exercises were developed and programs of remedial exercise and functional occupational therapy for specific muscle, joint and tendon lesions were adapted to meet individual cases in the later stages of convalescence. Each patient's program was prescribed by the ward surgeon. The patient making full recovery for return to general military duty was eventually placed on an eight-hour physical and military training program in a special section of the hospital or in barracks of a convalescent hospital. In military hospitals the number of freely ambulant cases remained large, and to confine these types of patients to ward routine too long was psychologically and physically deleterious. With a progressive physical reconditioning program, supplemented by specific remedial exercise, many serious surgical disabilities were benefited and salvaged for return to duty or prepared for return to civil life. The program was established in the bed stage of convalescence and carried through the progressive stages of recovery increasing in intensity in both its physical and mental aspects. To reproduce the entire series of exercises developed for this pro-

gram is not the purpose of this paper but for those interested in more detail, reference is available in published War Department Training Manuals, TM 8-292,⁵ 8-291,⁶ and 8-290,⁷ obtainable by inquiring at the Government Printing Office, Washington, D.C. However, it is considered of interest to produce those exercises designed for the bed patient and individually prescribed by the ward surgeon dependent upon the location of the lesion under treatment (very few bed patients could or should execute the entire series). (Figs. 1 to 6.)¹⁴

At the time of the peak load of patients in hospitals in the zone of interior over 25,000 patients a week were being returned from Army Hospitals reconditioned for some form of military duty. However, as the more serious battle casualties increased in numbers in the General and the Convalescent Hospitals and reached a stage of recovery considered to be stationary or resulting in permanent disability, more attention and emphasis was placed on the programs for reconditioning patients for return to civil life. This program,⁸ therefore, was altered to include vocational guidance and exploratory pre-technical or pre-vocational training and less physical conditioning, while the Station and Regional Hospitals, receiving training casualties, emphasized return to military duty.⁹

Of the special programs developed for special types of seriously wounded surgical patients, three are worthy of special mention (1) amputee,¹⁰ (2) thoracic surgery,¹¹ and (3) spinal cord injury.¹² Space will not permit for a detailed description but ready reference is available for those interested by making inquiry of the Office of The Surgeon General, U.S. Army, the Pentagon Building, Washington 25, D.C. These particular types of patients required special corrective exercise and training in specific conditions to become adjusted to a changed environment. The amputee training in the use of prosthesis developed special programs for upper and lower extremity cases, such as, training in the use of arm prosthesis in a telephone pay station booth and

Starting Position



48. CONDITIONING DRILL FOR CLASS 4. See table I.

EXERCISE 1: RAISE AND PUSH

Cadence. Slow.

Starting position. Lying on back, hands grasping the sides of the head of the bed about 8 inches above the level of the mattress.

Movement.

(1) Push down toward the floor with the hands, pushing hard enough to lift head and shoulders slightly from the bed. Do not assist this movement with the abdominal or thigh flexor muscles. Do not bend the head forward.

(2) Recover to starting position.

(3) Push with both hands overhead in a direction away from the feet, and at the same time pull the hands together inward toward the middle line of the bed.

(4) Recover to starting position.

The principal muscles used in this exercise are the shoulder muscles and those of the upper back which adduct the upper part of the shoulder blades (upper and middle trapezius and rhomboids). The other muscles of the arms and forearms are used secondarily.

23

EXERCISE 1A: ALTERNATE LEG RAISER

Cadence. Moderate.

Starting position. On back, feet together.

Movement.

(1) Raise left leg upward to the vertical.

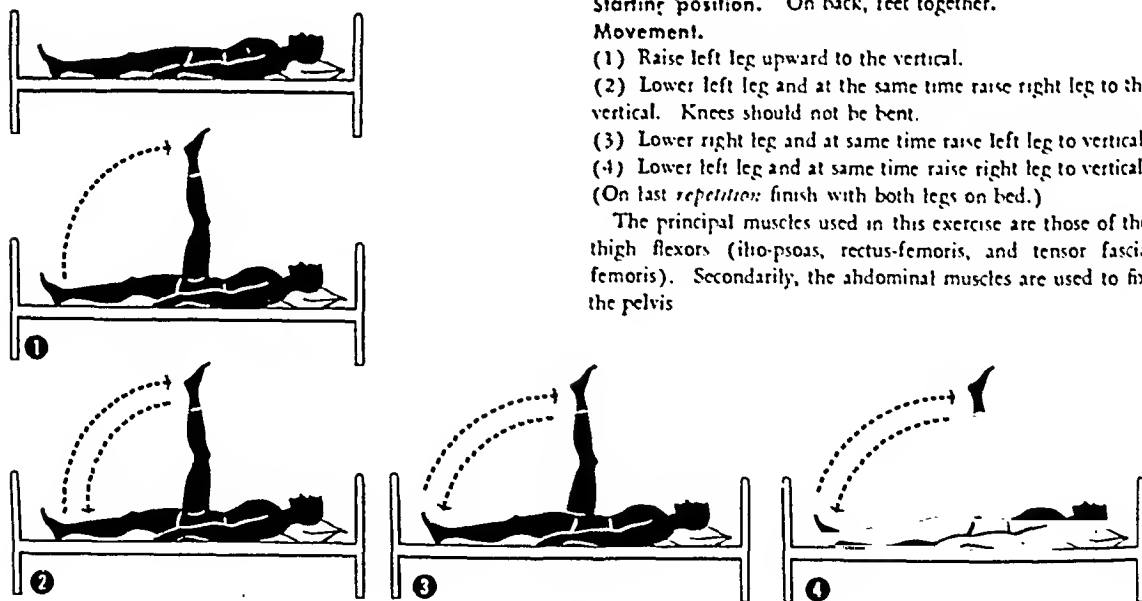
(2) Lower left leg and at the same time raise right leg to the vertical. Knees should not be bent.

(3) Lower right leg and at same time raise left leg to vertical

(4) Lower left leg and at same time raise right leg to vertical (On last repetition finish with both legs on bed.)

The principal muscles used in this exercise are those of the thigh flexors (ilio-psoas, rectus-femoris, and tensor fascia femoris). Secondarily, the abdominal muscles are used to fix the pelvis

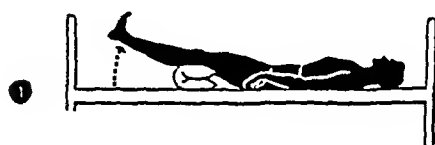
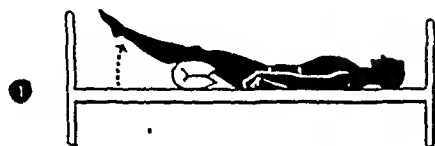
Starting Position



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FIG. 1.

Starting Position

**EXERCISE 2: LEG STRETCHER**

Cadence. Moderate to slow.

Starting position. On back with pillow doubled and placed under the knees, arms by side. Feet together.

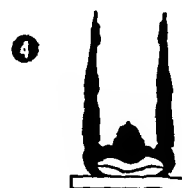
Movement.

- (1) Straighten knees and point toes downward, forcibly resting knees on pillow; grip hands hard.
- (2) Recover to starting position, opening hands hard.
- (3) Straighten knees hard and raise toes, pushing forward hard with heels and gripping hands hard.
- (4) Recover to starting position, opening hands hard.

The principal muscles used in this exercise are those which extend the knees, and those which extend and flex the foot and hand. If disability to one foot or leg exists, this exercise should not be executed on that side.

25

Starting Position

**EXERCISE 3: SHOULDER BLADE SQUEEZER**

Cadence. Slow.

Starting position. On back, arms forward (towards ceiling).

Movement.

- (1) Swing arms sideward and backward, and press arms hard against the bed.
- (2) Relax slightly, and press again.
- (3) Repeat count (1).
- (4) Return to original position.

26

FIG. 2.

Starting Position

**EXERCISE 3A: CHEST RAISER****Cadence.** Moderate.**Starting position.** On back, arms by sides.**Movement.**

- (1) Raise chest forcibly and inhale deeply, press backward against bed with head and arms. At the same time, contract all of the back muscles and extend toes downward hard.
- (2) Recover to original position.
- (3) Repeat count (1).
- (4) Recover to starting position.



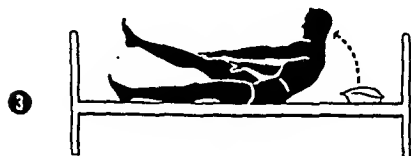
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EXERCISE 4: CURL AND TWIST**Cadence.** Moderate.**Starting position.** On back, arms by side, feet separated about 2 feet.**Movement.**

- (1) Raise head and shoulders from bed, raising right shoulder the higher. Touch left knee with right hand, and at the same time raise left leg about 6 inches off bed.
- (2) Recover to starting position.
- (3) Repeat count (1) to other side.
- (4) Recover to starting position.

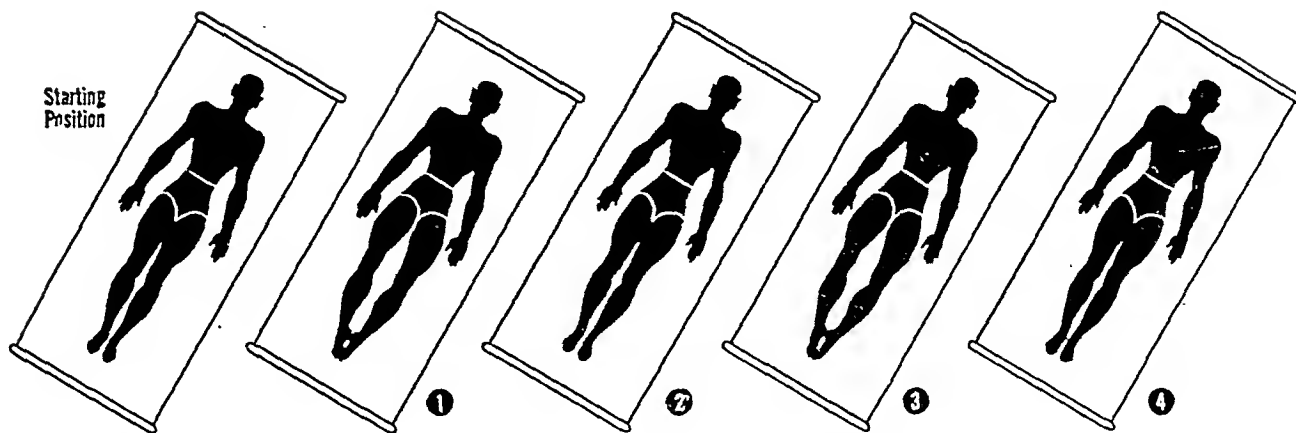
The principal muscles used in this exercise are those of the abdomen and those which flex the thigh.

Starting Position



28

FIG. 3.

**EXERCISE 4A: FOOT SUPINATOR**

Cadence. Slow.

Starting position. On back, arms by sides, toes pointed downward.

Movement.

(1) Bend ankles inward until soles of feet are together and knees are very slightly bent; press soles together hard.

(2) Recover to starting position.

(3) Repeat count (1)

(4) Recover to starting position.

The principal muscles used in this exercise are those which supinate the feet, the muscles of the soles of the feet, and the adductors of the thighs. If the patient has undergone a recent abdominal operation, he should press his heels hard against the bed.

29

EXERCISE 5: BRIDGE RAISER

Cadence. Moderate to slow.

Starting position. On back with knees drawn up and feet about 2 feet apart. Fists are pressed on pillow at either side of head, elbows are elevated, and forearms are alongside of head.

Movement.

(1) Raise trunk from bed, resting weight solely on head, fists, and feet. Hips should be raised until the body is approximately straight from shoulders to knees.

(2) Recover to starting position.

(3) Repeat count (1).

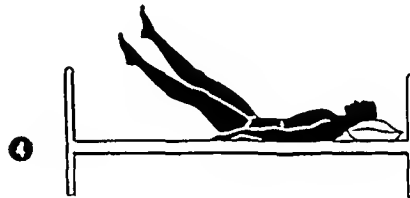
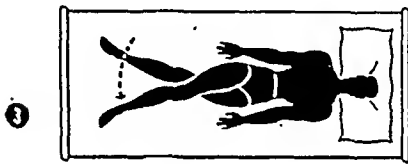
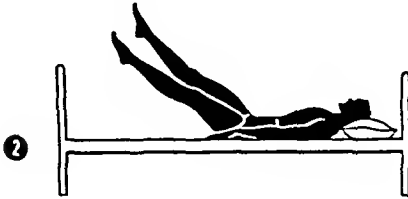
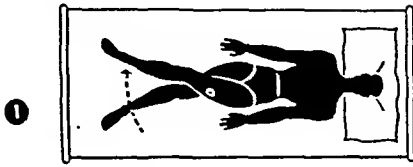
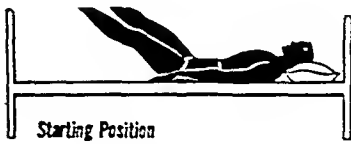
(4) Recover to starting position.

The principal muscles used in this exercise are the extensors of the whole body, neck, back, hips, and hamstrings. The extensor muscles of the back of the shoulders are also exercised vigorously. If properly executed, this exercise does not contract the muscles of the abdomen.

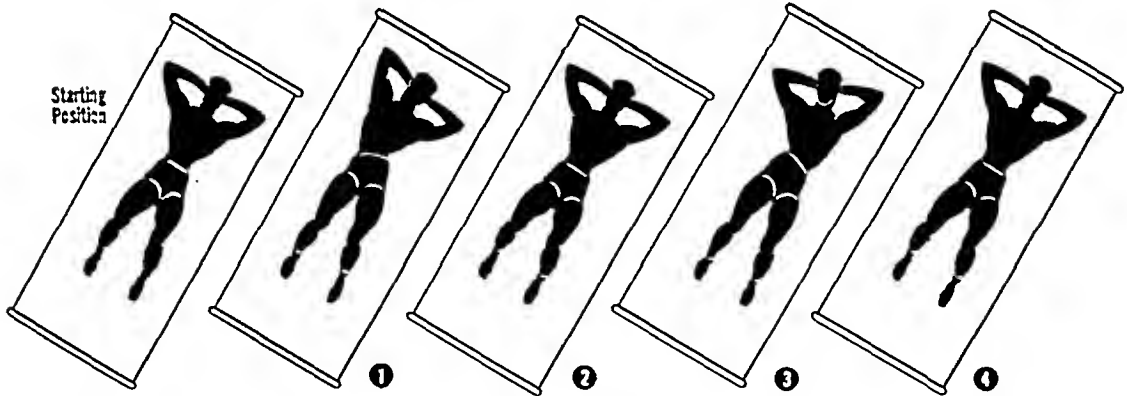


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FIG. 4-



31



EXERCISE 6: HIP SHRUGGER

Cadence. Slow.

Starting position. On back, hands behind head, knees fully bent, and feet about 18 inches apart.

Movement.

(1) Raise left hip from the bed and "shrug" it up towards the armpit on that side as though trying to bring top of hip bone under the armpit. (The hip movement is like raising one foot

from the ground while standing with both knees straight.)

(2) Recover to starting position.

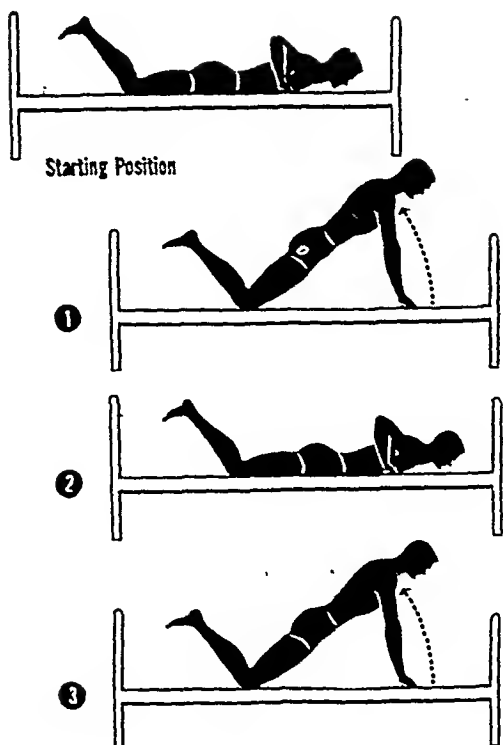
(3) "Shrug" the right hip upwards toward the right armpit in a similar manner.

(4) Recover to starting position.

The principal muscles used in this exercise are the muscles of the sides of the abdomen (quadratus lumborum, external and internal obliques, and the erector spinae muscles on the side upon which the shrugging movement is made).

32

FIG. 5.

**EXERCISE 6A: KNEE DIP**

Cadence. Moderate to slow.

Starting position. Prone on bed; arms at thrust, with fists resting on bed on either side of chest just below the line of the shoulders; and knees flexed.

Movement.

(1) Push downward with fists, raising the body in the ordinary push-up movement, but rest on knees rather than on feet. Body is straight from shoulders to knees.

(2) Recover to starting position.

(3) Repeat count (1).

(4) Recover to starting position.

The principal muscles used in this exercise are the thigh flexors; the muscles of the abdomen; those on the backs of the arms (triceps), the anterior shoulders (anterior deltoid) and the anterior chest (pectoralis major); and those which pull the scapulae forward (serratus anterior)



33

EXERCISE 7: FOUR-COUNT BREATHER

Cadence. Slow.

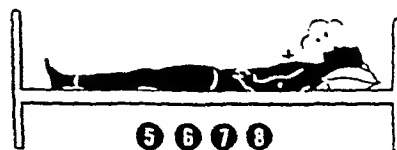
Starting position. On back, hands on hips

Movement.

(1-2-3-4) Inhale on four counts, taking a deeper breath on each count. Usually the patient will have inhaled fully by the third count, but he should try to inhale further on the fourth count.

(5-6-7-8) Exhale in "waves" in four counts. Try to blow all of the air out on the seventh and eighth counts

Starting Position



34

FIG. 6.

training in the use of leg prosthesis in the steps of modern dancing. The occupational therapists developed special training equipment for the arm cases and the physical therapists for the legs. Sports and games were an active part of this program and nothing was more stimulating than to see the baseball games played between the leg and arm cases at any and all of the seven amputation centers. In the thoracic surgery program special preoperative and postoperative breathing exercises were developed, greatly improving and shortening the convalescence of such cases. The fact that wounds of the chest of World War II have resulted in a minimum of serious sequelae can partly be attributed to the development of this special program at the Thoracic Centers. However, of even greater significance was the development in the Paraplegic Centers of an active program of rehabilitation whereby the greatest majority of the patients were taught independent ambulation and even those with cord transections learned not only to walk with braces but to mount a bus step and to take care of themselves in travelling on a week-end pass or convalescent furlough. Not all such cases will progress to sufficient recovery to be discharged home, but comparing the results of the last World War paraplegics with those of this World War, to date a marked improvement has been demonstrated. Special reconditioning programs for the blind and the deaf assisted notably in fitting them for proper adjustment to civil life.

Until such time as definitive end results are published, it is impossible to fully evaluate the Army reconditioning program. Much experience has been gained in the twenty-two months that the program operated most actively and much benefit was provided to patients in Army Hospitals. At the peak load of patients in the hospitals of the continental United States over 220,000 patients were participating daily in the reconditioning program and many soldiers were being discharged to duty or to civilian life better conditioned and bet-

ter informed than would otherwise have been possible.

Favorable evaluation has been placed on the importance of this reconditioning program by the Chief of Staff in his biennial report to the Secretary of War,¹³ "So that no casualty is discharged from the Army until he has received full benefit of the finest hospital care this Nation can provide, the Medical Service has established a reconditioning program. Its purpose is to restore to fullest possible physical and mental health any soldier who has been wounded or fallen ill in the service of his country.

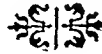
"To insure that men are properly prepared for return to civilian life the Army established 25 special convalescent centers. At these centers men receive not only highly specialized medical treatment, but have full opportunity to select any vocational training or recreational activity, or both, they may desire. Men, for example, who have been disabled by loss of arms or legs are fitted with artificial limbs and taught to use them skillfully in their former civilian occupation or any new one they may select. Extreme care is taken to insure that men suffering from mental and nervous disorders resulting from combat are not returned to civil life until they have been given every possible treatment and regained their psychological balance."

In conclusion, it may be stated that the Medical Department carried out its mission of preserving the fighting strength of the Army with the development of its reconditioning program; that special programs were developed for each stage of convalescence from bed patient to full recovery; that special programs were developed for specific seriously wounded surgical patients, notably amputee, thoracic surgery and paraplegic as well as for the blind and deaf; and that not only were 58.8 per cent of the wounded returned to duty from the hospitals within the overseas theaters but that of those wounded returned to hospitals in the continental United States from overseas, considerable numbers recovered

to resume limited duty or were returned to civilian life better conditioned for the resumption of independent economic existence.

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SUTURES, combined with an anterior wire loop by the method of Martin, recommended by Campbell, make a very satisfactory reduction and fixation of a fractured patella. . . . Total excision of the patella as practiced by Brooke is not recommended as routine practice, but undoubtedly will give good results and may be used in extensive compound comminuted fractures.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

FRACTURES AND DISLOCATIONS OF THE SPINE IN WARFARE

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IN the history of mankind is chronicled a steady progression of means of devastation and destruction equaled only by the ingenious methods that have been devised for their prevention and repair. During the recent war, until the days of its conclusion, the application in warfare of instruments for destruction failed to gain the ascendancy. The employment of a new source of energy, previously unimagined by the uninitiate, tipped the scale so alarmingly on the side of destruction, that one questions not only whether an equalizing advance will be made, but whether such an advance will be possible.

It is assumed that such progress is possible, and it is hoped that knowledge, gained by experience, particularly that acquired in warfare, will aid, at least in small measure, in starting the balance back on its long course in the desired direction.

A notable achievement during the second world war was the capacity for action on large scale and in wide scope. It is apparent that this is true in all phases of medicine and surgery. There were greater numbers and varieties of single and combined injuries than ever before. Injuries of the spine were no exceptions. However, to attempt to present a complete report of injuries to the spine would be impossible for obvious reasons.

This résumé is a rather brief recounting of a modest experience at a Naval Mobile or Fleet Hospital on a Pacific island, and at one of the larger Naval Neurosurgical Centers.

It is desired to recount the methods of caring for casualties arriving at the Naval counterpart of the Army Base Hospital in the Zone of the Interior, the treatment

during this hospitalization, evacuation to the mainland, the problems pertaining thereto, and experiences at a fully equipped and staffed Neurosurgical Center. Fractures and dislocations of the spine were so frequently associated with injuries to the spinal cord that these cases were admittedly better handled by these activities.

PROBLEM OF EVACUATION

The line of evacuation of Naval casualties, particularly from the various medical activities on the beach-heads, pointed directly to fleet or base hospitals situated on islands selected because of their geographical position on sea lanes homeward and because of their climate and relative security. With each advance toward the enemy home islands, it became necessary to transport evacuees over greater distances. This was done chiefly by surface craft, and principally by vessels of the amphibious force. In the earlier days of the campaign in the Pacific, before the arrival of the landing craft, transportation of the wounded was carried out by large Naval transports returning from the initial lands, air-transportations when landing strips had been secured, and inter-island evacuation by Hospital Ship. As larger islands were secured and consolidated, air transportation assumed greater proportions and regular flights were scheduled. The availability of these various means of transportation as continuously subjected to the demands of the overall logistics for the Pacific strategy, and which repeatedly was reflected in the total number of units available for the evacuation of casualties. This obviously mitigated against any rigid plan which would regulated length of hospitalization at the various medical ac-

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tivities along the line of evacuation down through the Islands and, to some extent, evacuation to the continental United States.

It is readily observed that the problem of evacuation in this theater was somewhat unique, in that the wounded marine, sailor, or soldier, by the time he arrived at a Fleet Hospital or Naval Base Hospital, whether he had a fractured spine with a complete paraplegia, or a leg wound, had been carried through jungle mud or over coral to the nearest aid station, possibly in a Stokes stretcher to the Marine Regimental or Battalion Hospital on the Beach. From this point, he was carried to an adjacent L.S.T. for a voyage which, at times, may have been many hundreds of miles to another island where he was admitted to a Naval Base Hospital after a short trip by ambulance or jeep. Following a stay at this hospital of a week or two, depending on transportation and the need for beds, he again embarked, perhaps on a Hospital Ship, for a voyage of possibly a thousand miles to a third island, and was admitted to a Naval Mobile or Fleet Hospital. The total mileage travelled up to this point may have been perhaps two thousand miles.

Local difficulties in the European Theater were, of course, encountered and the evacuation problem was subject to similar influences, mainly weather, which closed airports and roads. However, as in the opinion of War Department Observers there is no ideal method for handling these spinal cases in the type of warfare encountered in the Pacific and European areas. It was the aim of most medical officers to evacuate as speedily as possible all spinal cases to a properly equipped Neurosurgical Center, or in the Islands, to the Larger Naval Hospitals where there would likely be a Neurosurgical team. Unfortunately, this was not always the procedure. In some instances, spinal cases were treated in the more forward areas by relatively inexperienced or overzealous officers. Occasionally, paraplegics were incompletely treated dur-

ing the optimum period. Frequently, the latter was true because of transportation exigencies. However, no patient suffered because of lack of treatment. It was our practice to record the interval between the time of being wounded and first aid. There was no such interval longer than fifteen minutes, which is a tribute to the Hospital Corps.

Specifically, the over-all policy consisted of the following: In the care of spinal injuries rapid evacuation from the field, immobilized as far as possible to the aid station where a survey of the situation was made by the Medical Officer and the necessary emergency treatment started. Depending on the local situation, the patient was transferred either to the Beach Hospital directly or to a waiting L.S.T. or L.C.I. Aboard ship, or at the Beach Hospital, definitive surgical treatment may have been undertaken. Many of these cases had associated abdominal, thoracic or extremity wounds which not only necessitated immediate intervention but precluded rapid evacuation. During the voyage down the Islands the primary concern was treatment of shock, positioning of the patient, and perhaps the application of a plaster spica, the insertion of an indwelling urethral catheter and nutrition. The use of suprapubic cystotomy was somewhat unusual. The problem at sea was, of course, quite different depending upon the size of the ship, the amount of damage sustained by the vessel, etc. In this respect there were isolated cases even on large ships where the actual distance to the sick bay was not great but because of the distribution of the damage, circuitous routes through narrow passageways or small apertures became necessary. In such instances not only was some form of immobilization impossible, but in order to evacuate the patient, it became necessary to manipulate the spine disastrously so that the patient could be passed through a small aperture providing the only means of egress. Usually, however, the Medical Department of ships in combat had im-

mediately available the equipment and enlisted personnel to care for spinal cases; the patients were then evacuated either directly to a hospital ship, or transferred upon the next island stop. None of the Naval Hospitals in the area was designated as a Neurosurgical Center, therefore, the line of evacuation was more or less the same for all types of injuries.

The Naval Base Hospitals and the Mobile or Fleet Hospitals were the chief focal points at which evacuation of casualties to the mainland was decided upon and carried out. These hospitals were authorized to hospitalize patients up to a period of four months. This period was judiciously selected and proved advantageous. It allowed a sufficient period of time for definitive treatment, and equally important was the fact that during this time the patients with spinal injuries, particularly the paraplegics, could be prepared for the voyage of six thousand miles across the Pacific. A cruise of this length would ordinarily present a hazard simply by reason of total distance travelled. There was also the added difficulty of days spent in equatorial waters, below decks with perhaps no cooling system, encumbered by a plaster jacket, tidal drainage apparatus, and the individual's knowledge or suspicion that he might never walk again, that he was going home a cripple.

On arrival at the West Coast, the spinal cases were admitted to the large Naval Hospitals where each individual situation was again evaluated and treatment instituted as indicated. However, it was the policy of the Bureau of Medicine and Surgery of the Navy to transfer all patients needing prolonged hospitalization to the Naval Hospital nearest their homes. This directive was amended in 1945, with the designation of four Continental Hospitals, two on each coast, as Neurosurgical Centers. Thereafter, spinal injuries with nervous system complications were directed to these centers.

The frequent handling and admissions to many hospitals of the Naval casualties,

and of course Army Personnel in the same area, necessitated by long distances travelled, point out the application of a newer concept concerning the position of the patient with a fractured spine while being handled. It has long been the common opinion that hyperextension, or at least extension, were the positions of choice. This was, and is true of fractures of the vertebral bodies, particularly in cases of anterior body fracture. It has been observed by many that in war injuries of the spine, particularly gunshot wounds, usually it is the vertebral arch that is fractured, the body remaining intact. Hyperextension in this type of fracture will produce additional damage to the cord by projecting fragments further into the spinal canal.

This type of injury should, therefore, be anticipated early and assumed to be present, especially when neurological signs exist, and the patient is best transported in either a neutral or prone position. The indiscriminate use of the position of hyperextension during handling before an accurate diagnosis is established should be abolished.

CAUSATIVE FACTORS IN SPINAL INJURIES IN WARFARE

All types of injuries produced in civilian life occur for the same reasons in wartime in addition to those incident to combat. The frequency of occurrence of the civilian type of spinal injury is increased; however, this is due primarily to the acceleration of activity. Not only do more men and women drive vehicles and fly planes, but they do so with greater speed and less care. Further, more numerous vehicles of warfare are driven and flown around and about civilian areas. The personnel for civilian traffic control is depleted. With the demand for greater production in wartime and the consequent almost total conversion of industry to war production, the incidence of civilian injuries of this type also increases.

In actual warfare there were new variations of the old types of missiles producing

spinal injuries, notably, the high-velocity bullet, the Samurai sword, incendiary bullet, aerial-bomb and torpedo. It is interesting to note that in our experience, and so far as it has been possible to determine, no shrapnel such as that used in the first World War has been used in this war. Actually, shrapnel, named for General Henry Shrapnel (1761–1842) of the British Army, is a case or shell provided with a bursting charge, filled with balls, and exploded in flight by a time fuse. The use of the term, shrapnel, as it is employed today is not to be confused with the above and would be better discontinued. It is frequently used to describe bomb, mortar and shell fragments. The two most frequent agents in the Pacific which produced injuries to the spine were mortar fragments and Japanese .25 caliber rifle bullets.

On large island bases, the most frequent etiological source was truck and jeep accidents. Aboard ship falls into the holds, explosions resulting from enemy action and falls elsewhere about the ships, particularly in foul weather, produced the greatest number of fractures and dislocations of the spine. At sea there were, occasionally, unusual instances in which severe spinal injuries were produced as a result of explosions and torpedoing. There have been instances of spinal injuries produced by the Japanese Samurai sword, employed with the intention of decapitation which, fortunately, almost invariably failed and then at the cost of the life of the wielder. This sword can penetrate steel helmets and produce compound depressed fractures of the skull. New etiological factors during the recent war were land mines, small craft such as motor-torpedo boats, and delayed action aerial bombs timed to explode below decks, injuring those above. It is of interest in respect to the latter, that a man standing erect upon an exploding deck is more likely to sustain fractures of the os calci than a fractured spine. There were no instances of bayonet or knife wounds which produced damage to the spinal cord in our series.

CARE OF SPINAL INJURIES IN THE FIELD AND AT SEA

As already indicated, the ideal attempted in the field was prompt first aid and early evacuation of spinal cases to medical activities equipped and staffed to treat this type of injury. By the early establishment of Neurosurgical Centers in the zone of the Interior, the relatively greater facility for evacuation to rear echelons by reason of shorter distances and adequate transportation, the expeditionary Army in the European Theater was commendable. The organizational plan for the management of casualties having spinal injuries provided for rapid evacuation of these cases from the Battalion Aid Stations to the closest collecting stations, thence to the nearest evacuation hospital by ambulance; at this point, neurosurgical teams were available. According to the availability of transportation and the need for hospital beds, neurosurgeons in the forward areas were directed to carry out the surgical procedures indicated, reflecting credit upon those responsible for the plan. A similar plan was not in operation in the Pacific. As already indicated, there were no such centers in that area, and spinal cases were routed down through the Islands, stopping at hospitals where there may or may not have been a neurosurgeon.

In general, there was uniformity of agreement in the outline of treatment for spinal injuries. Simple fractures without wounds or involvement of the spinal cord presented no great problems as a rule, excepting those with displacement of bone fragments which endangered the cord. These were usually recognized early and treated accordingly with immobilization or traction. Those with combined injuries, in which the cord was damaged, obviously required more complex treatment. The necessity for early, complete, surgical intervention, under proper conditions, was perhaps not so fully appreciated in general. There was rather wide agreement with the necessity for the prevention of urinary

sepsis and improvement of the general condition of the patient. The latter was not always achieved for several reasons. The prevention of hypoproteinemia, at times, failed and consequently decubitus ulcers became serious complications. It is of interest that this was observed more frequently at a Naval Neurosurgical Center in patients admitted from other Continental Medical Activities than were seen at a Naval Fleet Hospital in the Pacific. It is recognized that these patients had been wounded in action as long as a year previously. However, they had been in the United States for many months during which time there was ample opportunity to treat the old ulcers, and certainly to prevent new ones, which was the case with the group above mentioned.

In the forward areas, uncomplicated spinal injuries or such injuries without associated wounds were the exception rather than the rule. The most grave, immediate threat to the patient's life was, of course, hemorrhage, and secondly, shock. With these under control attention could be directed more earnestly toward the spinal injury, with an accurate determination of the neurological situation. This was recorded on the patient's health record. The importance of these records cannot be overemphasized for it was possible in many instances for the Medical Officer at the next station to which the patient was admitted to have had knowledge of a progression of involvement of the spinal cord at a time when surgical intervention would afford the greatest chance for recovery. Likewise, incomplete information handicapped the surgeon in the rear areas. It is recognized, however, that during the stress of combat it was not possible for the surgeon in the forward area to pass along any information regarding the patient. One Army Medical Officer in the field will long be remembered with gratitude for having written a brief but pertinent note in pencil on a strip of adhesive tape which was attached to the patient's upper chest recording important neuro-

logical observations existing shortly after injury. The level of paralysis and sensory deficit had ascended during evacuation, and knowledge of this change by reason of the adhesive tape note was valuable.

Casualties were admitted to the Naval Mobile or Fleet Hospitals usually in fairly large numbers. As many as five to seven or eight hundred in a group. With such a sudden influx of wounded, and frequently they would be Army, Navy, and Marine Corps Personnel, early availability or records was necessary. The Army patients we saw had their records in jackets pinned to their clothing in an obvious place. The Navy health records were collected together aboard ship and sent directly to the hospital record office for official "admission" of the patient to the hospital. Notes were easily made on the Army record. The Navy records were repetitious, cumbersome and not with the patient.

Fractures, dislocations, and fracture-dislocations of the vertebral column without injury to the spinal cord or cauda equina, after the initial treatment for shock, etc., were completed, were managed according to the level of injury. Only by means of careful neurological examination and detailed x-ray studies of the area implicated could a rational approach to reduction be made.

In the cervical region, reduction was best accomplished by the method described by Hoen¹ and the method of Crutchfield.² The method described by Stookey³ was used to advantage for cooperative patients without fractures involving the posterior neural arch. Certainly patients handled in this manner are the most comfortable. The first two methods mentioned were most satisfactory for the reduction of fractures in which there was marked displacement of fragments and, in particular, for attempting reduction long after injury. In this regard, the greater security afforded by the method of Hoen in which stout wire is passed through burr holes in the skull makes it superior to the Crutchfield tongs which occasionally slip-

ped. The protagonists for the tongs will argue that they will not slip when applied correctly which is true. However, since it is the simpler method it was employed on occasion by some not quite adept in its application. With both methods, weights greater than fifty pounds have been used.

Skeletal traction was applied for periods of three to five weeks depending on the type of fracture and the particular components of the spine injured, following which a plaster spica was applied. None of our patients were evacuated in traction. Those patients in which the lower cervical spine was fractured, especially mild compression fractures of the anterior aspect of the body, were simply placed in a plaster cast and evacuated aboard the next available transport.

In the thoracic region, the same was true for the group comparable to that last mentioned. No satisfactory method for adequate reduction of marked dislocation (more than 50 per cent lateral displacement), or for situations wherein vertebral bodies are compressed to two-thirds their normal width have been forthcoming in our experience. These injuries are rare, however, without damage to the spinal cord or cauda equina. It has been observed in our series in a few instances that it is possible, in the presence of such marked lateral displacement of vertebral bodies, for the cord to remain in intact anatomical continuity. With knowledge gained in the war that return of some function is possible even when decompression is undertaken many months after the original injury, this fact contains important implications. Without such marked displacement of vertebral body fragments, and when not complicated by fractures of the laminae or pedicles, the automobile-jack method of Ryerson⁴ was employed. The use of the Bradford frame, when extension was indicated, was rather unsatisfactory in that it tended to promote bed sores, so that when possible, Stookey's method was used.

The above outline of management ap-

plied also to fractures of the lower spinal column with the additional use of the method described by Watson-Jones.

Uncomplicated injuries to the sacrococcygeal region were rare, not severe, and readily amenable to the conservative measures outlined above.

Fracture, fracture-dislocation and dislocation resulting from injury sustained in combat, associated with damage to the spinal cord and cauda equina, formed by far the larger group. Of this group, cervical cord injuries occurred in 10 per cent of the cases, 23 per cent were upper thoracic cord injuries, the lower thoracic injuries comprised 34 per cent, and the cauda equina was involved in 33 per cent of the cases. These figures do not represent the overall statistics but are personal observation.

With experience, surgeons have learned that not only is the question of whether the spinal cord is intact or not of paramount importance, but how much and what can be done at the Base Hospitals or at the Neurosurgical Centers in the Zone of the Interior to minimize the disabling effects of complete anatomical interruption of the cord. Also as the result of wider experience, he has learned that the clinical criteria for complete section of the cord were surprisingly erroneous at times casting doubt upon the justification for conservatism. The multiplicity of wounds, observations that not all "complete paraplegics" conform to the classical pattern described by Riddoch,⁵ the occurrence of pain below the level of section, and others, presented the World War II surgeons with perplexing problems impossible to solve immediately and obviously giving evidence of incomplete knowledge, rendering the solution more complex and difficult. The availability of the sulfa drugs and the antibiotics removed some of the restrictions upon surgery. As a result of this experience, new reasons for more radical measures were added to the prevailing list of indications for surgery as outlined by Mixter,⁶ Wortis and Sharp,⁷ Browder and Grimes⁸

and others. In addition, the surgeon had come to realize that rehabilitation should begin for the wounded man soon after injury and that the rôle of the surgeon in the forward area could be one which might determine an adequate adjustment of the patient to his disability. By the judicious maintenance of hope for some recovery when indicated and the assurance of a useful comfortable existence without economic burden to others in complete paralyses, more lives are salvaged.

The management of injuries of the spine with associated damage to the cord and cauda equina has been conditioned by knowledge gained in overseas and Continental U. S. Hospitals which has altered, to some extent, the indications for surgical intervention in these cases. Careful observation and wider experience have tended toward a somewhat less conservative attitude than existed prior to the onset of the war.

The following outline of the indications for surgery does not include the conditions thought to have necessitated surgical intervention at all times during the war, but includes those indications added as the result of later experiences.

INDICATIONS FOR EARLY SURGICAL EXPLORATION IN WAR CASUALTIES

Incomplete or Complete Cord Lesions in Which There Is Progression of Cord Dysfunction. This situation was considered to be as urgent an emergency as hemorrhage from an important blood vessel.

Involvement of the elements forming the posterior portion of the neural arch compressing the cord, or in danger of compressing it, if adequate reduction of the displaced fragments cannot be achieved and maintained closure and repair of the dura when penetrated by bone fragments were indications for surgery.

Fracture, fracture-dislocation and dislocation, and foreign bodies such as bomb fragments, etc., at the "critical level" of the spinal axis (from the sixth cervical segment of the cord to the first thoracic segment in-

clusive)! Between these two segments 80 per cent of the fibers forming the brachial plexus emerge. Loss of function of the brachial plexus renders the patient a practically helpless invalid. Preservation of about 60 per cent of the brachial plexus enables a man to walk with crutches and, with care, to be eventually useful to himself and others. A great responsibility is placed upon the surgeon in deciding upon definitive treatment or no surgical exploration when called upon to treat injuries at this level. It is our opinion that certainly those patients in whom there is a partial paralysis and encroachment upon the canal should be explored immediately, as well as those with a complete paralysis when seen early. Those with a complete paraplegia, with definite roentgenological evidence of compression of the cord, or manometric block, should also be explored. Nicety of judgment is necessary when the x-ray evidence is not conclusive or the hydrodynamic examination carefully performed reveals only a partial block of mild degree. However, so much is at stake for the patient and so much is to be gained, that one must not be too conservative when confronted with this situation.

Removal of Foreign Bodies. The metallic fragments are sterile on entrance into the body. They should be removed when producing pain, if greater damage will not be done during their removal, when they have penetrated the dura, and there is a spinal fluid fistula through the portal of entry. Special attention has been directed by Lt. Col. J. L. Pool, A.U.S., to the consideration of penetrating wounds of the abdomen in which fragments lodge in the spinal canal and their likelihood of having perforated an abdominal viscus and of passing through the leptomeninges is emphasized. Flat surfaced, metallic fragments lying not entirely within the cord have been removed when the long axis of the fragment lies parallel to the long axis of the cord. The presenting portion of the fragment can be grasped with forceps and delivered along the plane of its entry after

space for its accommodation has been prepared by rongeur enough bone laterally.

Following gunshot and other penetrating wounds received in combat, closure of the dura for persistent cerebrospinal fluid fistula is indicated. The presence of a fecal fistula communicating with the meninges demands immediate attention.

Surgery for the relief of pain was rarely necessary in the early cases. Rhizotomy may occasionally be required, rarer still, cordotomy in the cases observed during the earlier weeks.

Two factors of importance were given some consideration. These were, first, the question of lumbar puncture. Not all spinal injury cases need lumbar puncture and the danger incident to manipulating the patients for this procedure realized. However, since most of these injuries involved the laminae and since the prone position was the one usually of choice for evacuation, more lumbar punctures were attempted in the prone position.

It was realized that the greatest damage to the cord was due to hemorrhage within the cord. When found and accessible, its removal was attempted from the midline.

One additional surgical procedure carried out in the European Theater which was infrequently performed elsewhere was suprapubic cystotomy in the paraplegics. It is agreed by most that the best method of caring for the paralyzed bladder is tidal drainage. With the large number of casualties in the European campaign and an insufficient number of trained enlisted personnel to care for the complex mechanism, the method of suprapubic cystotomy was justified and adequate.

MANAGEMENT OF SPINAL INJURIES IN THE UNITED STATES

Statistics following World War I regarding spinal cord injury revealed a mortality of over 90 per cent. Not in that war, nor in civilian life since then, until World War II has this type of injury been considered a special problem. They had been accepted as hopeless cripples, and as a

result of urinary sepsis and its sequelae, their early demise anticipated. The outlook for these casualties is no longer grim for all of them. Many can live out their normal expectancy of life, free from infection, and gain a livelihood. This was the goal of the Medical Departments of both Services and, although the final evaluation of their efforts is not at present available, much has been achieved toward that goal.

On evacuation to the United States, 80 per cent of the spinal cord injury cases had decubitus ulcers in addition to their paralyzes, many were undernourished, and in some cases were in marked hypoproteinaemia. The next most important complication to the patient after the paralysis was pain. They were worried men, eager that anything be done in order that they might walk again. The transition from the above picture to the hopeful, gratifying one outlined at the beginning of this section, was the result of teamwork among many neurosurgeons, urologists, orthopedic surgeons, internists, plastic surgeons, physical therapists, nurses and rehabilitation officers who, by their combined efforts, are demonstrating that approximately 50 per cent of all types of cervical cord injuries are walking and that between 60 to 65 per cent of all types of upper thoracic cord injuries are walking. Almost 75 per cent of the lower thoracic injury group are walking and as well as 90 per cent of the cauda equina injuries. It is true that most are ambulant with the aid of braces and crutches, either singly or combined, but it is indeed not rare that a soldier, sailor, or marine with a high thoracic lesion and a complete paraplegia, on discharge from a Service Hospital, drive off in his car to take a job.

The problem of management of casualties of this type begins immediately upon admission and individual cases re-evaluated. The malnutrition is eliminated by high protein diet, parenteral administration of amino acids, etc., whole blood transfusions when indicated, and vitamin therapy. The importance of returning normal nitrogen equilibrium is well recognized at

the centers, not only for adequate nutrition but also for the healing of wounds and decubiti. As soon as possible, when the patient's general health permits, he is measured for braces and started on exercises in bed before attempting ambulation. Meanwhile, if there has been a suprapubic cystotomy, this is closed and the patient started on tidal drainage and urinary problems are resolved so far as possible. The ideal, indicated by Munro, that an intelligent, cooperative patient who has sustained a spinal cord or cauda equina injury has a right to expect infallible twenty-four hour control of urination by the time he leaves the doctor's care, is attempted but the method of this achievement, especially when complicated, is beyond the scope of this outline.

The exercises performed in bed, in the wheel-chair or on a mat prepare the patient for ambulation and care of himself. The régime described by Deaver⁹ has been of value. When there has been adequate preparation of the five muscle groups necessary for manipulation of crutches and braces are found satisfactory, the patient is initiated into the mechanism of tripod-walking with crutches or when there is preservation, particularly of the iliopsoas, the "walk-through" technic is taught. The muscle groups necessary for standing up and walking with crutches are as follows, as enumerated by Deaver, in the order of importance:

"1. Arm flexors to move crutches forward.

2. Extensors of the forearms to hold elbows stiff so they do not buckle when body weight is lifted from the floor.

3. Finger and thumb flexors to preserve grasping the crutches:

4. Dorsiflexors of the wrist to keep the hands in correct position on the hand pieces.

5. Shoulder girdle depressors and downward rotators to support the body by means of the crutches when it leaves the floor.

As already mentioned, complete sections

of the cervical spinal cord preclude the possibility of walking on crutches because the nerve supply of these groups emerge from the cervical cord. Long, bilateral braces are necessary for paraplegics to stand or walk on crutches. Exercises in bed, in a wheel-chair, the gymnasium mat, and parallel bars are designed to develop those muscles of the above group which are preserved. Once the patient is capable of ambulation on the flat floor surface he is taught the technic of climbing a ramp and stairs."

Reconstructive surgery in the Centers is directed toward the greater return of cord function, the relief of pain, spasticity and contractures. Many very late laminectomies have been performed in the presence of partial lesions and block with surprisingly gratifying results. Operations for the relief of spasticity include the following: anterior root resection, obturator neurectomy, tibial neurectomy, tibial nerve section and neurorrhaphy, tenotomy and alcohol injection of the spinal cord. Operations for relief of pain include posterior root section, cordotomy, sympathetic ganglioramisectomy, cordectomy (at level of lesion), peripheral nerve section and alcohol injections.

CONCLUSION

Much credit has been given to the various specialists engaged in treating patients with spinal fractures and dislocations and their achievements during the recent war. Little mention has been made of the patients themselves. Universally, the morale was highest among these severely injured men. Their youth and general health prior to combat, together with an indomitable will to recover and be useful citizens, contributed to the success of their treatment in equal measure.

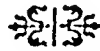
SUMMARY

A general outline of the management of fractures and dislocations of the spine in warfare is presented, based only on per-

sonal experience and observations of others engaged in similar work and not intended to represent a complete picture of the problem.

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SPINA bifida may be hidden (spina bifida occulta) or obvious, innocuous or part of a widespread deformity incompatible with life. Together with its related diseases it is most common in the lumbosacral region, next common in the cervical vertebrae, and least common in the thoracic spines.

From "Surgical Treatment of the Nervous System" edited by Frederic W. Bancroft and Cobb Pilcher (J. B. Lippincott Company).

ACUTE WAR WOUNDS OF THE SPINAL CORD

ANALYSIS OF 184 CASES

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THE treatment of injury of the spinal cord has been characterized by conservatism. Closed spinal cord injuries rarely call for surgical intervention.¹ The many advances in surgical adjuncts have been helpful. Crutchfield skull traction tongs are used to great advantage in the treatment of cervical spine injuries. Hyperextension is useful in the treatment of closed dorsolumbar fractures compromising the cord and frequently allows surgery to be avoided. Munro's contribution is nowhere exceeded by the development of his tidal drainage apparatus for the treatment and control of the neurogenic bladder.² His analysis of spinal cord injuries and their treatment, and his excellent results in rehabilitation of the patient with a transected cord, have contributed much to our knowledge.³ The trend, however, in the treatment of acute closed spinal cord injuries has been toward the conservative and only rarely has laminectomy been considered of value.⁴

Cushing, in his report as Senior Consultant of Neurological Surgery during the last war, discussed spinal cord wounds only to lament their almost invariable pitiable result and early death.⁵ As a consequence of this extremely conservative attitude the problem was dealt with hesitantly in the early days of the present war. A pessimistic attitude was assumed during the author's African and Sicilian experience. Very stringent indications for operation voluntarily governed the various neurologic surgeons functioning in that theater. As a result, the usual operation following a spine wound was merely a débridement. X-ray evidence was relied upon to a great

degree, denoting transection or sparing of the cord by the missile's passage through the neural canal. A progressive neurologic lesion would occasion operation, but those patients exhibiting such a lesion were few. It was assumed that spinal cord damage was irreversible and much was made of the rapidity of onset of the paralysis. No one of us was ever satisfied with the defeatist attitude prevalent as to the prognosis of cord wounds. Yet, in the light of previous experience of such men as Cushing, and the results of surgery in hardly comparable closed cord injuries, it seemed foolhardy to laminectomize more of those patients.

Only three laminectomies for trauma were performed by the author in the Mediterranean theater, although twenty-six such patients were observed. One patient had a progressive cauda equina lesion with a bullet in the neural canal. The other had an incomplete lesion, slowly progressive, and a spinal fluid block with x-ray evidence of an incomplete, unilateral, laminar fracture. These two patients obviously needed urgent surgery. There were many others whose need was not then so obvious, but who now would be operated upon unhesitatingly. Radiculitis, caused by facet and laminar fractures, was treated conservatively. All clinically complete lesions were sent back with only a tissue débridement.

All in all, the dictums of civilian experience, in so far as pertaining to laminectomy in wounds of or near the spinal cord, were unsatisfactory to the surgeon's mind and conscience. The depressing effect of finding at operation a transected or softened cord was persistent. Yet, it was accepted knowledge that if any improvement was to be

* Dr. Haynes, formerly a Lieut. Col. in the Medical Corps, Army of the United States, is now retired.

expected, direct pressure of bone, debris and foreign bodies must be removed early, preferably under forty-eight hours. The cauda equina, if involved, must be untangled. Spinal fluid fistulas must be closed. There is no natural reparative process which will replace surgery in such conditions.

These same thoughts and dissatisfactions were being shared in the Zone of the Interior. Although assurance was not such that a general statement could be made, Colonel R. Glen Spurling at Walter Reed General Hospital,⁶ and other qualified men at other centers, were operating upon these unfortunates at a later date. The results seemed encouraging to them.

These thoughts occupied our mind as we prepared for the invasion of Normandy. The first few days were so hectic that spinal cord wounds were flown back to England without operation but with suitable fixation and hyperextension. The situation was so stabilized, however, by D 5-6, that laminectomy, under fair conditions, was feasible. The author, accordingly, began to laminectomize all spinal wounds with incomplete or progressive cord lesions, and eventually all those in whom he suspected the cord to be spared. These included those patients with a clinically complete lesion, with a block of spinal fluid by Queckenstedt test, and with the x-rays not indicating that the neural canal had been traversed. As consultant in Neurologic Surgery for the American First Army, he encouraged qualified men to perform laminectomies in such cases. It is too early to evaluate the eventual outcome of such decompressive surgery. It was learned, however, that almost all such cords were anatomically intact although physiologically they did not conduct impulses. This seemed encouraging and the scope of laminectomy was gradually increased. More and more anatomically intact cords were found in patients in whom all clinical and roentgenographic evidence seemed to indicate a complete transection.

It is realized that return of physiologic

function need not follow the mere anatomic sparing of the cord. Conversely, it is true that physiology cannot be resumed where anatomical continuity does not exist. As a primary step in the recovery of the patient, continuity must be ascertained or re-established. This can be accomplished only by laminectomy, just as such surgery can be justified only by an eventual return of function.

The most suitable place in the chain of evacuation for laminectomy is the first place wherein adequate talent and reasonable facilities for surgery co-exist. Since the need is urgent, the most suitable station is the Evacuation hospital. While nursing facilities are strained, the reward of being able to operate early upon a combined chest or abdomen-cord wound seems to justify the task. Otherwise those unfortunates will not be operated upon until their chest or abdominal wound allows evacuation, namely, from five to twelve days. Early surgery should cause less, rather than more, skin or bladder problems since reparation is frequently dramatic. Beds are not held for long periods of time because a laminectomized patient can be evacuated in three to four days if necessary.

SIGNS AND SYMPTOMS

The patient will speak of his inability, or partial inability to use his extremities, his lack of bladder control and his sensory loss. He may speak of an "electric shock" upon being struck, followed by immediate or progressive paralysis. The paralysis, however, may not be noticed in the mental haze of fighting, being wounded, and resultant shock. Rarely is the story of gradual onset of paralysis elicited and then its reliability is to be questioned. Three patients claimed a gradual onset of paralysis and all three had severed cords at operation. Patients suffering a concussion of the cord due to passage of a missile close to the cord, so-called "supersonic concussion," portray a paralysis which may be improving upon admission to the

Evacuation hospital. With no evidence of fracture, surgery is not indicated in these cases. It is indicated if bone distortion is present, since regression may occur to a point less than perfect, unless minimal bone pressure is relieved.

The patient usually is in a state of spinal shock, which persists for two or three weeks. The paralysis is flaccid and complete. Sensory loss is complete in all modalities. All reflexes are absent and the bladder is flaccid with urinary retention. Priapism is rare except in cervical cord lesions, complete or incomplete. Simple turgescence is seen frequently in cervico-dorsal lesions, occasionally lumbar. It, too, has little prognostic significance.

It was found that considerable confusion existed in the use of the term, "spinal shock." It is actually a neurophysiologic process with symptoms as described above, following transection, anatomic or physiologic, of the cord. It is later converted into the picture of spastic flexion, mass reflexes such as flexor spasms and usually a spastic automatic bladder. The term was confused, justifiably, with the state of neurogenic shock, seen following cord injuries. This latter syndrome is portrayed as a persistent low blood pressure, 70-90/0-40, normal or slightly increased pulse rate, ashen color, lethargy, cold skin but normal hematocrit and blood count. Such a picture was to be expected at the level of C-7 or D-1, because of the ciliospinal group of cells and the proximity of the stellate ganglion. It was attributed in other locations to the blood loss and consequent vascular shock, due to the concomitant wound. This view was, of necessity, discarded. There is no air hunger, restlessness or distorted hematocrit and whole blood in quantities does not alter the picture. Rather a gradual return to normal is seen, extending over a period of two or three days or even longer, regardless of treatment.

Ileus was a very common, persistent and annoying finding and was controlled only by a Miller-Abbott tube, suction, and laminectomy. Prostigmine helped in the

re-establishment of tone in the gut wall but the response to surgery was more dramatic. The presence or absence of ileus was of little prognostic value. It occurred impartially in severed or intact cords, but when it was present, it occurred in physiologic severed cords. It was not seen in a clinically incomplete lesion. Type of breathing exemplified only the level of the lesion and aided in prognosis as to life. Cervical cord lesions below C-4 allowed only diaphragmatic breathing. Those patients in this series all died. Lower lesions, allowing only a small amount of costal expansion, caused pulmonary complications and, sometimes, early exodus.

One prognostic sign of some import was noted. A clinical level of anesthesia and paralysis would ascend, probably due to ischemia and softening, to two or three segments above the bony level indicated in x-ray. This sign usually indicated a completely transected cord. Again, however, it was not infallible.

Radicular pain was seen most frequently in incomplete lesions and constituted an indication for surgery. This pain could be extreme and uncontrollable, particularly common in cervical or cauda equina wounds.

Sensory loss is dependent upon the tracts severed or compressed. The lateral spinothalamic tract carrying pain and temperature impulses and the ventral spinothalamic tracts carrying light touch impulses are the most important. Proprioceptive sensation, carried in the posterior columns, may be lost directly. All the variants of a true Brown-Sequard syndrome have been seen, the textbook picture, rarely. However, a partial lesion of the cord, may, if spinal shock is not complete, allow light touch to be preserved. This is because of the gradual crossing of the ventral spinothalamic tracts. Such an instance, of course, is an indication for laminectomy. Prognostically, sensory retention is more important than motor loss. The pyramidal tracts are apparently the most susceptible to trauma. Complete motor loss is the rule

whereas some retention of light touch is commonly seen in incomplete cord lesions.

The sensory loss of pain and temperature may be confirmed by the lowering of skin temperature, loss of perspiration and the peculiar dry, flaky feeling of the denervated skin. These characteristics are discovered by drawing the fingertips lightly over the body surface. There is also a minimal, mottled discoloration of the anesthetic skin.

Associated thoraco-abdominal cord wounds are very common. This necessitates delay in surgery for the cord wound, since the thoracic or abdominal wound takes priority over the cord wound. Physiologic respiratory factors, in such cases, demand local anesthesia for the laminectomy. It is desirable also to accomplish the spinal cord surgery within forty-eight hours after the time of injury. If this cannot be done without endangering the patient, it is believed that the next most favorable time period is under ten days and that the prognostic difference between forty-eight hours and ten days is of minimal significance. The opportunity to accomplish the most for the patient with a cord wound is under forty-eight hours.

INDICATIONS FOR SURGERY

The indications for laminectomy were in a state of flux. Their scope was gradually extended to include actually any patient in whom there was a reasonable doubt that the cord had been severed. Lack of the gift of lucid expression clouds the exact pictorial description of this suspicion. Surgery cannot restore anatomical continuity where the spinal cord has been severed. It can, however, permit restoration of physiologic continuity if the cord is intact and only compressed by bone or foreign bodies. Despite common and loose descriptions of compression of the cord by blood clots, this phenomenon was never seen.

Tissue débridement is indicated in all wounds of or near the vertebral column or

spinal cord. Devitalized tissue, débris, foreign bodies and accessible, removable bone fragments should be excised. Positive evidence of transection of the cord would allow one to do only this, to close any spinal fluid fistulas by means of a fascial graft and to close the muscle and skin tightly. Except for the closure of muscle and skin, this is no more than is done to any war wound. The necessity of a tight dural closure, plus local instillation of sulfonamide and penicillin powder, is obvious. Fractured spinous processes are commonly removed in such instances. Rarely, if ever, is it necessary to remove a fractured transverse process. Fascia of the paravertebral muscles is readily available for dural grafts to close spinal fluid fistulas.

Laminectomy. Obviously, any incomplete or progressive neurologic cord lesion, associated with a wound of, or near, the spinal cord, requires laminectomy. This is a self-evident truth and is universally accepted. The only exception to this rule would be an improving neurologic picture with no x-ray evidence of bone damage. This type of supersonic concussion of the cord is not helped by surgery, and improvement is usually spontaneous and rapid. However, an improving neurologic picture associated with laminar damage should still demand laminectomy. A return to less than normal may be replaced by complete recovery if minimal bony compression is removed. This is an important dictum.

A complete physiologic lesion demands surgery if there is any suspicion that the spinal cord is intact. Experience dictates that the cord is anatomically intact in a high percentage of such lesions. Yet, to operate each one would subject the patient to unnecessary major surgery and waste needed time. A number of factors operate to formulate the suspicion that a cord may be spared. It is not believed that any one of them, or any combination thereof, will allow one to state definitely that a cord is or is not transected.

Neurologic examination can reveal only the degree of completeness of the lesion. It

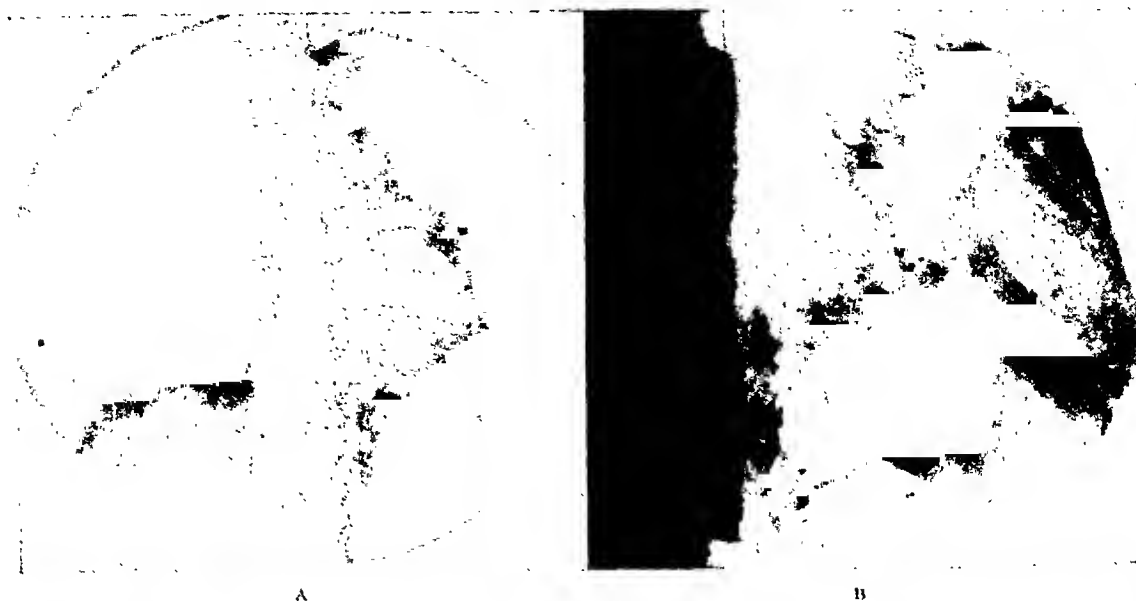


FIG. 1. Minimal x-ray evidence of damage at D7-8-9-10. Operation revealed complete destruction of cord at that level.

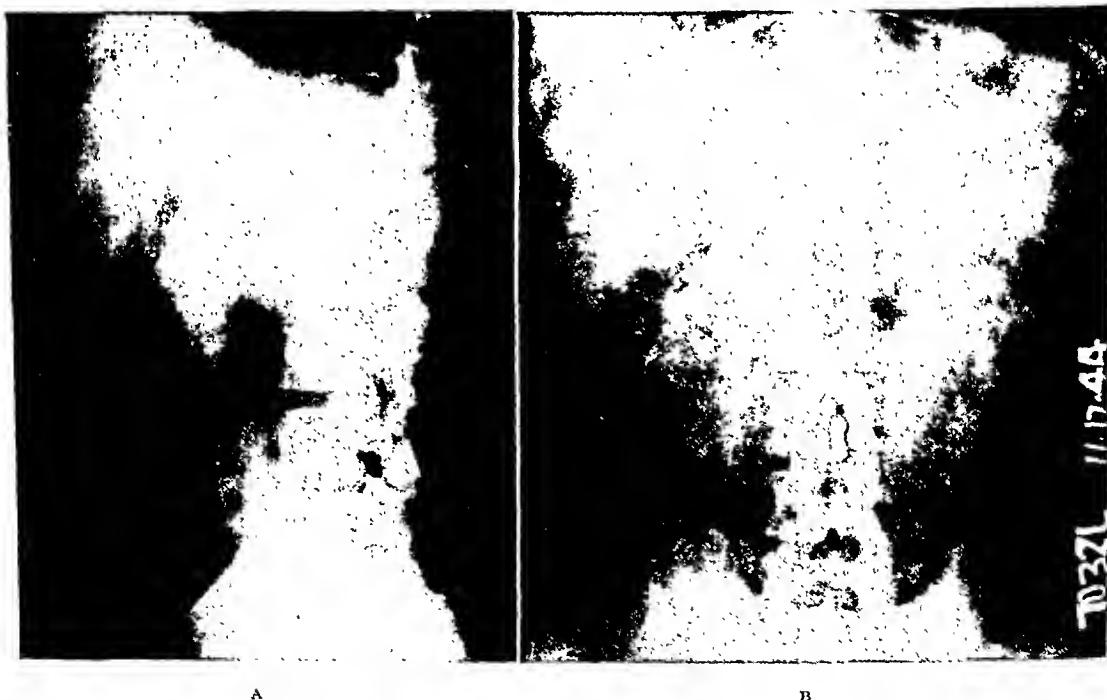


FIG. 2. This missile crossed the neural canal and should have transected the cauda equina. Yet, at operation, the cauda was intact.

is of no help if the lesion is clinically complete.

The various stigmas described above, such as ileus, priapism and an ascending level of anesthesia are only contributory factors in arriving at a decision. No one is reliable as to sparing or transection of the spinal cord.

Roentgenographic evidence in the field without a moving Bucky diaphragm does not present criteria for acceptance or rejection of a patient for laminectomy. It is, however, the most reliable of all the above indications. The amount of laminal damage is difficult to evaluate by x-ray. The obvious ones are no problem, but a very



FIG. 3. A and B, pre- and postoperative x-ray of missile at D7. Hemi-laminectomy is difficult to see in x-ray.

minimal amount of damage by x-ray may be revealed at operation as gross damage with cord transection. (Fig. 1.) Conversely, apparent crossing of the neural canal by a large fragment with marked bony damage, may be revealed as a lesion sparing the cord. (Fig. 2.) Facet deformities are even more difficult to recognize because of technical drawbacks inherent in field equipment.

The Queckenstedt test to determine the presence or absence of a spinal fluid block, actually is of little value in estimating suitability for operation. A negative Queckenstedt may be found in a partial cord lesion, the very case needing urgent operation. Conversely, almost every complete transection of the cord will reveal a block of cerebrospinal fluid by Queckenstedt because of the local tissue damage and debris. To rely on such a test for this purpose is foolhardy because it tells us nothing. For teaching purposes, to assert that every block should be relieved is acceptable, but many transected cords will be found. To reject every negative test is to miss the patients one may help the

most. A minimal lesion after all recovers the fastest and most completely.

Consequently, a collective and judicious survey of all these unreliable factors must be made to determine operability. Experience is the greatest attribute and such experience is rare and hardly found since comparable civilian wounds are few. Error on the side of superfluous surgery is to be preferred to error on the side of conservatism. It would be better, if only more humane, to operate many hopeless patients to save one. Irrefutable evidence of cord transection, however, should obviate unnecessary surgery. The burden of proof lies on the side of determining a transected cord. The cord should be assumed spared until it is proved to be transected.

Hemi-laminectomy has come to fill a very useful rôle in war surgery. (Fig. 3.) Unilateral severe radiculitis, due to traumatic distortion of facets and intervertebral foramina, may be relieved by this procedure. Removal of foreign bodies from the neural canal is expedited. Unilateral cord compression by fractured lamina can be easily relieved. It is a particularly useful



FIG. 4. Unilateral cord compression at C6 relieved by hemi-laminectomy.

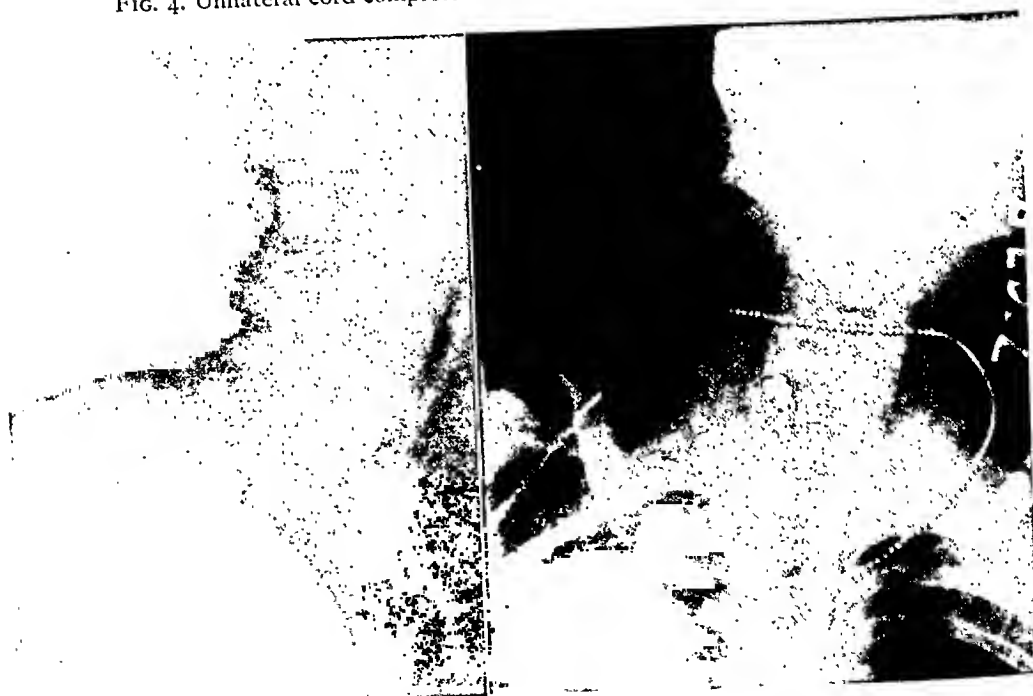


FIG. 5. Unilateral cord compression at C5-6-7 relieved by hemi-laminectomy.

procedure in the cervical region. (Figs. 4 and 5.) Indeed, it seems to be the only necessary procedure since all the patients requiring a wide laminectomy died. The reason obviously is that any foreign body crossing the neural canal in the cervical region will occasion death. (Fig. 6.) Unilateral damage, not seriously injuring the vital cervical cord, can be repaired through

a hemi-laminectomy. Some of the best results of spinal cord surgery have come through this procedure.

Occasionally, extreme and uncontrollable pain, even in the presence of a transected cord, was noted. This pain was radicular in distribution and was on two occasions intractable to re-operation, decompression of the proximal nerve roots



FIG. 6. Large shell fragment crossing neural canal at C5-6-7, transecting cord and causing death.

and even posterior rhizotomy. Intrathecal alcohol had no effect on the pain nor did sympathetic paravertebral blocks. It is believed cordotomy may be indicated in such cases. Ammonium salts intrathecally (Pitcher plant extracts) may have been of some value.

The problem of severe and painful flexor spasms or mass reflexes was not seen in this early phase. Therefore, the need to con-

sider anterior or posterior rhizotomy, nerve crushing or the use of curare, did not arise.

Technic does not vary from accepted technic anywhere. Local anesthesia is used frequently but endotracheal gas-oxygen-ether, and even sodium pentothal, is also commonly used. The dura mater is always opened unless the wound is dirty or old. There need be no fear of meningitis with the adjuncts of penicillin and sulfonamides.

TABLE I*

	Pts.	Operated	Incom- plete Physiol.	Complete Physiol.		Preop. Deaths	Postop. Deaths	Over-all Mort. Rate	Postop. Mort. Rate	Some Ret. of Function (6 Wks.)
				Anat. Comp.	Anat. Incomp.					
Cerv.....	35	10	3	3	4	10	3	37.1	30.0	7
Dors.....	81	29	6	5	18	2	3	6.1	10.3	8
Lumbar.....	66	35	8	4	21	0	0	0.0	0.0	14
Sacral.....	2	2	0	0	2	0	0	0.0	0.0	1
Total.....	184	76	17	12	45	12	6	9.8	7.9	30

* Those patients not operated upon were adjudged to have had their spinal cord transected or battle conditions were such as to make laminectomy not feasible. Very rarely did the general condition of the patient contraindicate surgery. Postoperative cervical deaths were due to transected cord. Postoperative dorsal cord deaths were due to abdomen-chest wounds. Cervical cord wounds that survived and improved had had hemi-laminectomies; four so-called "supersonic concussion of the cord" cases improved without surgery in eight to forty-eight hours. Only three of twenty-nine spinal cord wounds were operated upon in the Mediterranean Theatre.

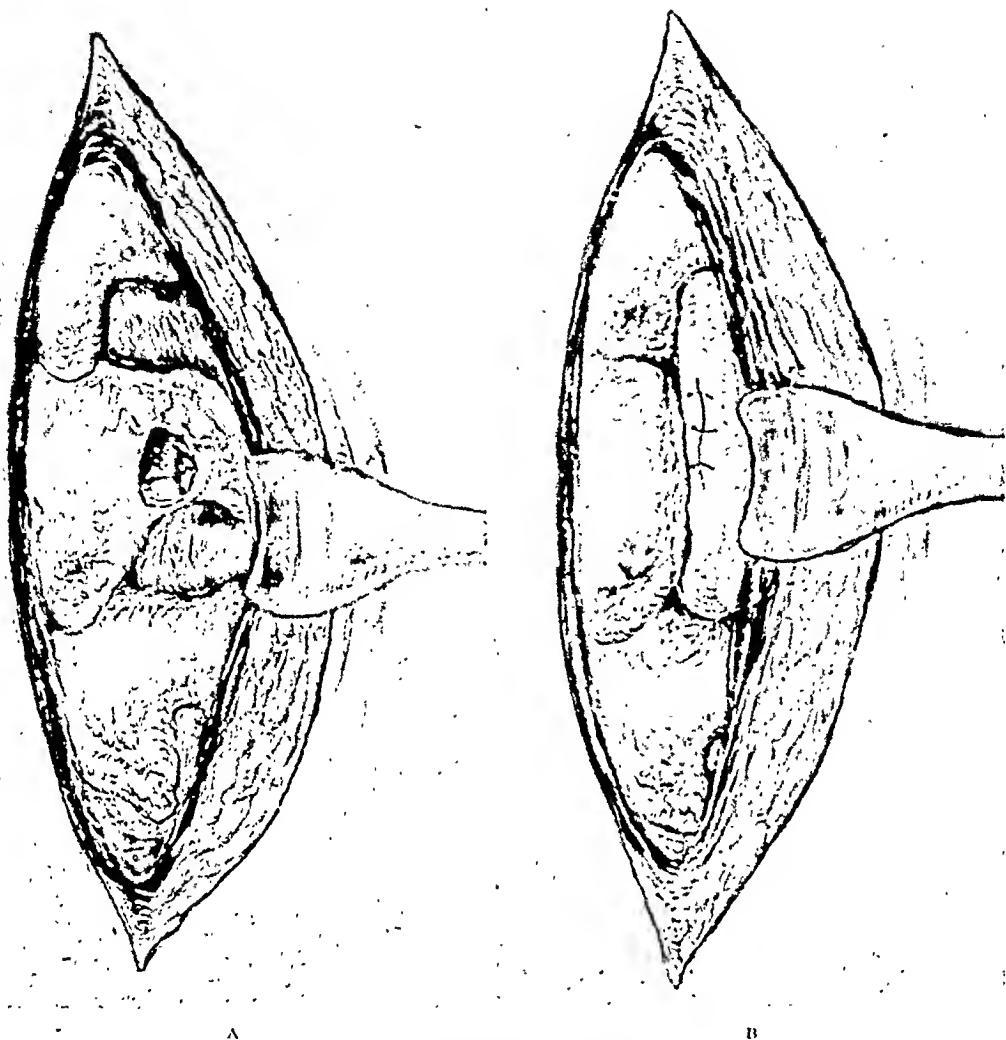


FIG. 7. Hemi-laminectomy necessary for removal of missile in Figure 3. Illustration was developed from author's operative sketch.

The author has seen no infections in this series. Local sulfonamides and penicillin were instilled. Tight dural closure without drainage is always performed. The dura is closed with a fascial graft if necessary.

PROGNOSIS

Study of Table 1 will reveal an over-all mortality of all patients with spinal cord wounds reaching the neurosurgeon alive of 9.8 per cent. Postoperative mortality rate was 7.9 per cent. Cervical cord wounds caused a 37.1 per cent death rate, over-all, and 30 per cent postoperatively. The mortality rate of dorsal cord wounds was 6.1 per cent over-all, and 10.3 per cent

postoperatively. Lumbar and sacral wounds caused no deaths. These rates are calculated on a ten-day period and constitute immediate mortality. Those patients with transected cords may survive for varying periods until the usual bladder or decubitus infections are fatal. Although tidal drainage was used on all bladders in the early phase, it was rare that a patient with a spinal cord wound reached the United States without a suprapubic cystotomy. This is not an indictment *per se* of tidal drainage apparatus, since facilities and personnel for constant supervision were lacking.

Seventy-six laminectomies revealed only twelve transected cords; 108 patients, how-

ever, had been rejected as being inoperable because of a transected cord.

Thirty patients had a return of function of some degree following laminectomy. No return was noted in patients not operated upon, except in four patients with concussion of the cord and no bone damage. Seven patients with cervical cord wounds recovered function, everyone whose cord had not been severed. Eight patients with dorsal wounds recovered function, twenty-one did not and three died. Fourteen patients with cauda equina lesions had a return of function out of thirty-five patients operated upon; twenty-one did not, but none died. Thus, of the seventy-six patients laminectomized 18.4 per cent (fourteen patients—four cervical, three dorsal and seven cauda equina lesion) had some return of function within ten days. Within six weeks 39.4 per cent had a return of some function. Further follow-up has not been done as yet. It is believed that improvement may continue up to one year. Therefore, it may be assumed that a greater percentage will be eventually benefitted. The author believes strongly that proper and prolonged care and rehabilitation of these unfortunates may allow some progress in the over-all picture. Complete and exacting study and care of skin, bladder and general condition may allow technical rehabilitation to the point of social usefulness. It may also allow a healthy mental readjustment, a much needed ally of the physician. Postoperative deaths occurred only in those patients with severe associated wounds, except for the cervical cord wounds, who died quickly of respiratory failure.

SUMMARY

Pessimistic attitude regarding spinal cord wounds has been recounted. Gradual

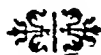
shift of opinion has led to increased number of laminectomies and fairly encouraging results. Unreliability of clinical signs and x-rays as to cord section is emphasized. Prognosis as to life and return of function after laminectomy is evaluated. Indications for laminectomy and hemi-laminectomy are described. A careful and exacting study, care and rehabilitation program is indicated, and may provide a clue for further improvement.

CONCLUSIONS

1. Anatomically transected spinal cords are fewer, in gunshot wounds of the vertebral column, than formerly believed.
2. Physiologically transected cords may recover if compression is relieved by early surgery.
3. Early laminectomy is indicated if any question exists as to sparing of the spinal cord.
4. It is believed that all cauda equina lesions should be explored.
5. Thirty-nine and four tenths per cent of seventy-six spinal cord wounds operated upon had some return of function in six weeks.

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MANAGEMENT OF WAR WOUNDS OF THE CRANIAL CAVITY

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IN the main, the general principles for the management of war wounds of the cranial cavity were established by Cushing during the first World War. The exigencies of war at time led to certain variations in the execution of these principles for the locations of the battle fronts and methods of evacuation of the wounded were not always the same. Events sometimes dictated methods and at times evolved new principles. It was necessary to take climate into consideration in the management of these patients. This was certainly true in the tropics. As would be expected, the time interval between wounding and the time definitive treatment could be given played a definite rôle in governing the type of therapy to be used. Because of these various factors, this report will be a general outline of the management of war wounds of the cranial cavity as experiences dictated them in the China-Burma-India Theater.

GENERAL

At the beginning of the campaign in North Burma, evacuation of the wounded was slow because of transportation problems. Thus patients with head wounds did not reach a hospital where definitive treatment could be given for three to five days or even more after wounding. The forward hospitals were not equipped to do this type of surgery but did some débridement and frequently closed the wound in order to tide the patient over days of transportation. Those wounds which were left open arrived at the neurosurgical center in relatively good condition although a few were infected. The closed wounds, on the other hand, were in a number of instances in-

fectured and these had to be opened. As a result of these observations and the fact that air evacuation of the wounded was subsequently established, an organized plan was set up for the handling of all head wounds.

Those medical units which had no equipment and were without trained personnel, such as the Portable Surgical, Field and Evacuation Hospitals, were instructed to administer shock therapy and emergency treatment to the wound. After the patient had reacted from shock, he was evacuated directly to the station where definitive therapy could be given. Cooperation was excellent and by the time the campaign reached its height these wounds were receiving definitive treatment within twelve hours after wounding, or within twenty-four hours at the very latest. This system worked so effectively that it seemed to us unnecessary to consider placing a Portable Neurosurgical Unit within the active combat zone. This was especially true since a battle front in the traditional sense did not exist in the jungle.

EMERGENCY TREATMENT

The therapy advised in the forward units was that the wounds be cleansed, that hemorrhage be controlled, and that the wound be dusted with sulfanilamide crystals and an appropriate dressing applied to the entire head. No penicillin was then available.

The head was to be shaved all about the wound for a minimum distance of three inches or, if time permitted, the entire head. The wound was to be washed with a sterile solution of soap and then irrigated with a sterile normal salt solution. Hemor-

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rhage from the scalp was to be controlled by suture ties and hemorrhage from the brain by gentle pressure with dry sterile cotton pledgets or ligation of the vessel if it could be seen. (No fibrin-foam was available in this theatre during the entire period of combat.) Following irrigation of the wound, the surface of the wound was to be dried and dusted with a light layer of sulfanilamide crystals. Sterile gauze dressings were to be applied to the wound, the head padded with gauze or cotton and the dressings covered by a gauze handkerchief and fastened moderately tight to the head by gauze bandage so that it would not come off during transit.

Procedures which were not advised were as follows: No excision was to be made of the scalp edges, dura or brain tissue unless they were very loosely attached. Bone fragments were not to be removed since they might be acting as a plug to a vessel or sinus which, when released, might cause uncontrollable hemorrhage. Plaster of paris or crinoline bandages were not to be used as a head dressing for these materials shrink while drying and necessitate cutting to prevent unbearable pressure which might easily endanger the blood supply to the scalp.

SHOCK THERAPY

Many of these patients were treated by elevation of the foot of the litter, while others were kept flat. No harm in the form of dangerously increasing intracranial pressure or the precipitation of hemorrhage seems to have occurred in those on whom the head-down position was used. In fact the reaction from shock seems to have been hastened without untoward effects. Thus observations made in many patients support the use of the head-down position in patients with wounds of the cranial cavity in the treatment of shock. A further advantage of this position is that in the unconscious patient it permits the secretions to collect in the nasopharynx from which they can be removed by wiping or aspiration.

It was rarely necessary to use more than one blanket during the day because of the tropical heat. In severe cases, and during the night of the dry season, when the air temperature dropped to 50°F. or below, it was necessary to use both blankets and heat.

Where blood loss was partially responsible for the production of shock, whole blood was definitely more effective than plasma, although the latter served well as an emergency measure for resuscitation. It is surprising, in reviewing our records, to learn how few of the patients were given either plasma or blood. This is difficult to explain because many of the wounds were extensive, even though they were caused for the most part by small arms ammunition.

The use of intravenous fluids has been generally considered to be contraindicated in these patients. It was soon learned that this was not true. In the tropical climate most of the wounded were dehydrated and required fluids. Many of them, therefore, were given 500 to 1,000 cc. of sterile normal salt solution, with or without 5 per cent glucose. The intracranial pressure was not seriously increased and in fact, definite beneficial effects were seen from its use. From these experiences with the intravenous fluids in wounds of the cranial cavity more attention was given to the fluid balance of the patient and measures taken to maintain it.

The use of morphine sulfate in these patients was not recommended, although some did receive it. No particular complication followed its administration but the clinical picture was made more difficult to interpret. Our feeling is that morphine serves no useful purpose in the treatment of these wounds since pain is rarely a factor. Other drugs such as chloral hydrate and paraldehyde are more effective in the control of restlessness which is at times a serious complication.

AIR EVACUATION

It was our experience that head injuries stood air travel very well. Because of the

terrain the planes had to ascend to an altitude of at least five thousand feet during the trip. Only one patient had to be given oxygen during the flight. He was operated upon and made a good recovery from a rather extensive cranial wound. Although a few patients died while en route, it was quite obvious that air travel played no part in the course of the injury since the wounds were extensive and involved vital centers or large venous sinuses.

Frequently the large number of casualties and the perilous location of the forward medical unit made it necessary rapidly to evacuate the wounded. Patients with head wounds in varying degrees of shock were placed in the planes and transported to the neurosurgical center. Comparing the notes that came with these patients, and our own made at the time of arrival at the hospital, no significant alteration in the degree of shock was noted. Although this practice is not to be recommended, air transportation can be used for patients in moderate shock if conditions so demand, provided active treatment is continued during the period of evacuation.

A rigid vigilance was insisted upon over the unconscious patient during transit. Obstruction to breathing was to be prevented by keeping the patient on his side and if necessary the tongue to be drawn out of the mouth. Precautions were to be taken against the patient inspiring vomitus and against injury to the patient during a convulsion should these complications occur.

DEFINITIVE THERAPY

The principles of surgical treatment of penetrating, perforating and lacerating missile wounds of the cranial cavity which were used were: complete removal of all devitalized brain tissue, bone fragments and foreign bodies, water tight closure of the dura and closure of the scalp with drainage. Each of these structures—scalp, dura, bone and brain—will be discussed separately.

Before operation was begun three things

were given consideration: The *first* of these was an x-ray film of the skull. This was made in nearly every patient with a scalp wound no matter how trivial or extensive. This examination gives valuable information in two respects, namely, the extent of the underlying bone injury and the location of the bone fragments and opaque foreign bodies. Occasionally the surgeon was warned of possible hazards during the operation in that the bone fragments or missiles could be seen to lie close to a major vessel or venous sinus.

If circumstances prevented an x-ray examination of the skull before operation or if there was any doubt following operation that an incomplete operation had been done, the examination was made postoperatively when the patient's condition permitted it.

The importance of following this procedure was brought to our attention very dramatically. A soldier entered the hospital four hours after receiving an extensive wound of the cranial cavity. The data which came with him stated that he had been hit in the left occipital region by the recoil mechanism of a 75 mm. Howitzer. His condition did not permit a preoperative x-ray examination of the skull. Practically the entire occipital lobe, part of the temporal and parietal lobes had been destroyed. The devitalized brain tissue was removed, hemorrhage controlled, the dura repaired and the scalp closed by counter-incision. Without any warning and without evidence of increased intracranial pressure the patient had a convulsion on the seventh day which began as a right Jacksonian seizure and became generalized. He never regained consciousness and died about seventy-two hours after the attack. At the autopsy the area of the wound was clean. In the left occipital lobe close to the region of the pineal gland there was a shell fragment almost 2 cm. in diameter. It was in the center of an abscess which had ruptured into the pineal fossa. This fragment could have been reached and easily removed, had it been known that it was

present. However, we were misled by the historical data which came with the patient. As a result of this experience, routine postoperative films were made of all cranial cavity wounds.

The *second* point is the question of deferring operation until the patient has fully recovered from shock. In general this is good practice. However, we soon learned that too much time should not be allowed to elapse before operation because the wound itself prevents the patient from fully recovering from shock. A case will illustrate this fact: A Chinese soldier with a moderately extensive frontal lobe penetrating wound was admitted to the hospital with a temperature of 96.8°F., pulse of 140, respirations 36 and blood pressure 90/40. No further delay seemed indicated so the wound was excised and repaired under local anesthesia while the patient was given fluids and plasma intravenously. Upon return to the ward he had completely recovered from shock, having a blood pressure of 104/60.

This occurred in a number of instances and strengthened our impression that the removal of blood clots, divitalized brain tissue, bone fragments, and foreign bodies and controlling hemorrhage is part of the treatment for shock, when conservative measures fail to give a satisfactory response.

The *third* point concerns itself with the time interval between wounding and operation. There is no question that these wounds should be treated surgically as soon as possible after they have been inflicted. In the beginning of our experiences these patients came to the hospital three to five days or even more after wounding. Many of the injuries appeared relatively clean and without odor. They were treated as if they were clean by excision and closure with drainage. At first the wounds were dusted with sulfanilamide crystals. Later the practice of using local sulfonamide therapy was discarded. We had independently come to the same conclusion as did Ascroft from his African campaign experiences. These wounds can be considered

surgically clean up to forty-eight or seventy-two hours after wounding provided they appear clean. In fact Ascroft's results show that repairs done after twelve hours were attended with less complications than those done within the twelve hour period. Our results agree with his even though we were located in a tropical monsoon climate where it would seem that the opportunities were greater for the development of infection than on the tropical desert of Africa. In fact our observations lead us to conclude that wounds as old as five days which did not contain pus and had no odor could be treated as though they were clean.

These necessarily delayed operations were all treated by drainage of the scalp for a period of forty-eight hours or longer, depending on the amount of drainage. If infection did develop, it remained superficial and in no instance did a brain abscess, meningitis or osteomyelitis develop. This observation permits the conclusion that these wounds should not be treated until definitive surgery can be performed and as such are not the acute emergencies they were once thought to be, although the practice is not to be recommended for routine use in civilian practice.

SURGICAL TECHNIC

The *scalp* wound should be treated by excision of the edges back to healthy tissue. Conservatism should be exercised in this procedure because the scalp has a very rich blood supply and recovers remarkably well from injury. It is better to give questionably viable scalp tissue, where there is a possibility of re-vascularization, the benefit of the doubt rather than create defects which are large and extremely difficult to close.

The next step is the enlargement of the wound to provide adequate exposure of the bone defect and room to work upon the brain injury. This should be done with consideration of the blood supply and at least part of the plan for wound closure. If curved incisions in the form of a flap are

used, the base should include at least one of the four arteries of the scalp; supra-orbital, temporal, posterior auricular and occipital. A "tripod" exposure in which three radiating incisions are made from the wound is to be avoided because after closure the three opposing tips in the center invariably undergo degeneration and a hole results which must be repaired subsequently.

When there is a large defect the problem is at times very difficult. Many of these in our experience can be closed by a counter-incision. This means that when the original wound is enlarged, the extensions should be made in a straight or slightly curved line so that the counter-incision can be made parallel to it and a sufficient distance away to allow for blood supply as well as a wide enough strip to cover the bone defect. At least three inches should be allowed between the wound and the counter-incision. The latter does not have to be closed at the original operation but may be left open if the tension for closure is too great. In several of our patients in whom the counter-incision was left open closure took place without secondary operation. One in particular, in which the separation was at least three inches, closed leaving a scar of not more than three-quarters of an inch wide. The important thing in closing scalp defects is that the bone defect in every instance should be covered.

Bone. Bone should be removed to expose at least one inch of normal dura all about the defect. After this has been accomplished, the dural and brain lesion can be inspected and any additional bone removed for better exposure. When the bone defect is next to a venous sinus, it is best to start the procedure on the side away from the sinus and to make the opening rather large so that as the sinus is approached there is adequate room to take care of any injury to the sinus. In those instances in which a piece of bone has been driven in toward the sinus but remains attached to the intact skull edge,

it is most important to leave the piece of bone attached until sufficient has been removed on either side so that the sinus can be reached directly for the control of bleeding. Bone defects involving the frontal sinus or near it, and including it by fracture lines should include a wide opening of the sinus and removal of its membranes. The finished bone defect should have smooth edges and all bleeding should be controlled by a minimum amount of bone wax.

Dura. The edges of the *dura* should be trimmed and it is almost always necessary to extend the defect. Care must be exercised when doing this not to tear cortical vessels or damage normal brain tissue.

There are two views as to how the dural opening should be handled: The British believe that the defect should be left open. Their results, according to the reports in the literature, would suggest that this method does not increase the percentage of complications. We, on the other hand, believe that the dural opening should be closed in every instance and this view is generally accepted by American neurosurgeons. The advantages of repairing the *dura*, we believe, are that when infection develops in the scalp wound, it will tend to prevent the infection from spreading into the brain surface. When these healed wounds are opened for plastic repair, the procedure is rendered easier because a normal tissue plan has been provided.

In dural defects which are so large that direct closure is not possible, a graft of either fascia or pericranium should be used. Although these free grafts work very satisfactorily, they have the disadvantage that they are not living tissue. To overcome this we often used a pericranial flap in which the base of the flap remained attached to the intact tissue. A great many of the defects could be closed using this method. A smaller number were repaired by a sliding pericranial graft made similarly to closing of scalp wound by counter-incision. This method had the advantage of an excellent blood supply and of exerting an outward pull on the *dura*, drawing it tightly against

the bone edges and preventing hemorrhage from the surface of the dura beneath the bone after it had been sutured in place.

Brain. Treatment of the brain wound must include removal of all devitalized brain tissue, blood clots, bone fragments, foreign bodies, metal fragments and meticulous control of hemorrhage.

In wounds which involve vital areas such as the visual, sensory, motor and speech areas, it is most important to remove only the devitalized tissue. However, all of it should be removed, for if any is left, it increases the degree of scar tissue or may form a liquified collection, both of which may cause convulsions. Its removal is best effected by a good suction apparatus.

Second only in importance to the excision of devitalized brain tissue is the extraction of all bone fragments and foreign bodies. A piece of bone left in the brain substance serves as an excellent nidus for the development of a brain abscess. Of the brain abscesses that developed following wounds of the cranial cavity in our series approximately half were associated with retained bone fragments. Metal fragments, we found, presented a different problem. Frequently they lodged in the brain substance at a distance from the wound of entrance making it necessary to extract them through a separate opening. In general we left missiles less than 1 cm. in diameter which were not easily reached whereas those which were larger were removed.

Meticulous hemostasis should be established before the procedure can be considered complete. For this purpose fibrin-foam is said to be unequalled by those who have used it. We have had no experience with it. The cavity of the entire tract should be irrigated with at least 200 to 300 cc. of warm, sterile, normal salt solution through an asepto-syringe or sufficient fluid to have the washings return clear. If the cavity is deep or the tract long, a catheter attached to a syringe simplifies the problem. The purpose of irrigation is to wash out all the detached

brain tissue or other foreign material that has not been detected.

Closure. The first wounds which we treated were dusted with sulfanilamide crystals before closing. This practice was stopped because no particular benefit was observed by its use and the tissues did not seem to heal as well when this was done.

Fine black silk or cotton was used for closing both the dura and the scalp. In a few instances fine steel wire was used to repair the dura and it is believed this is a better material, for if infection should develop in the scalp and silk has been used, it is necessary to remove all of the sutures. The vertical interrupted mattress suture proved the best for scalp closure. The edges of the wound were accurately approximated and the sutures were removed at the end of five days.

The scalp should always be drained with rubber tissue for twenty-four to forty-eight hours.

POSTOPERATIVE CARE

Oral or parenteral chemotherapy should be used prophylactically in all these wounds. We used sulfadiazine in full doses because penicillin was not available at the time our initial casualties arrived. With its use a careful watch had to be kept over the fluid intake because renal complications were common in the tropics if the fluid intake was not adequate. This prevented the employment of dehydration and caused us to keep a careful fluid balance in the patient. The value of the drug is undisputed for a rapidly spreading streptococcic infection was almost never seen.

The postoperative care was not particularly different from the management of patients from whom tumors have been removed. A routine taking of temperature, pulse, respirations and blood pressure every half hour for the first twenty-four hours and then less frequently as the clinical picture indicated should be made in all patients. Besides increased intra-

cranial pressure the result of edema or hemorrhage, one must be constantly on the look out for infection. Cerebral edema responds in most cases to conservative measures such as lumbar puncture and dehydrating agents. If no benefits are derived from this treatment and the wound looks clean, it should be explored for the possibility of hemorrhage. A subtemporal decompression should be done, if no cause for the pressure is found.

A wound that appears to be infected should be partially opened; and if pus is recovered, the entire scalp wound should be opened, accepting the inevitable development of a cerebral fungus. The treatment of this condition is beyond the scope of this paper. The infection in the wound was controlled best in our hands by packing it with gauze sponges saturated with penicillin. These packs were renewed every six hours for a period of two or three days as the infection dictated. After the infection had subsided for about one week, a secondary closure was performed or the edges strapped together.

The unconscious patient demands constant expert nursing care. Among the special things which must be closely watched in patients with head wounds is the free passage of air. Partially obstructed air passages increase intracranial pressure. The patient should be kept on the side, never on the back. If this is not effective, the tongue should be drawn out or an airway inserted. Before mucus begins to collect in the trachea, the foot of the bed should be elevated so that it will drain into the nasopharynx from which it can be either wiped out or aspirated at regular intervals. Rotation of the patient should be done every two hours for it is in these

patients that pressure sores develop with great rapidity. The incontinent patient should be treated with an indwelling catheter without further delay, for it simplifies nursing care especially when there is a large group of patients and personnel is short. Tube feedings should be instituted after the first twenty-four hours of unconsciousness and at least 1000 calories be given in each twenty-four hour period. At the same time careful watch should be kept over these patients for the development of complications such as postoperative hemorrhage, infection in the wounds, pulmonary and renal complications.

SUMMARY

A résumé has been given of our experience in the general management of war wounds of the cranial cavity during the Burma campaign. These experiences revealed that wounds could be treated as clean up to five days after wounding, provided they appear clean and have no odor, which is in agreement with Ascroft's report of his African experiences. All bone fragments and missiles 1 cm. in diameter or larger must be removed because they serve as a nidus for the development of an abscess. The local application of sulfonamides seemed to have no beneficial effect in preventing infection. Prophylactic oral or parenteral sulfonamide therapy or penicillin is essential in the treatment of these wounds and has practically eliminated the occurrence of spreading streptococcal wound infection. In a tropical climate it is more important to maintain a fluid balance in these patients than to place them on a régime of dehydration.



PENETRATING WOUNDS OF THE BRAIN*

MANAGEMENT IN AN EVACUATION HOSPITAL

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AT the onset of the first World War the operative mortality from penetrating wounds of the brain was 55 per cent. By the end of that war Cushing was able to report forty-six cases with an operative mortality of only 29 per cent. At the close of World War II the mortality from this type of wound was about half of Cushing's best figures.

What were the reasons for this improvement? The surgical principles employed were essentially the same as those used during the first World War, namely, débridement, arrest of hemorrhage and usually repair of dural defects. The slight variations of Cushing's technic were the result of modern innovations such as the electro-surgical unit and suction apparatus rather than fundamental technical variations.

There were more significant reasons for this reduction of the postoperative mortality. The advent of sulfonamide and penicillin therapy must have been a vital factor. The protection afforded by chemotherapy increased the "safe interval" for primary definitive surgery to such an extent that concepts accepted as late as the onset of World War II became out-dated. The performance of primary definitive surgery in well equipped, forward echelons was a contributing factor. An abundant supply of whole, citrated blood and dried plasma permitted long, shocking surgical procedures which otherwise would have proven fatal. Finally, the improved organization of medical echelons surely contributed to the results obtained.

All forward neurosurgery was not done by formally trained neurosurgeons. In some hospitals it was done by general surgeons with a limited neurosurgical experience. This report records a portion of the experiences of two medical officers who fell into the latter category. It is based upon 122 consecutive cases operated upon by the authors during a period of fourteen months in the Italian campaign.

During this period there were 12,501 admissions to the surgical service of the Eighth Evacuation Hospital. Of these, 8,660 were battle casualties. It is impossible to state accurately the total number of neurosurgical admissions. However, a total of 222 neurosurgical procedures were done during the same period. Approximately 200 of these were operations upon battle casualties. Hence nearly 3 per cent of battle casualties were neurosurgical in nature. Cranial surgery was performed upon approximately 200 patients. Among these, 139 had penetrating wounds of the brain. This represents slightly less than 2 per cent of battle casualty admissions.*

A penetrating wound of the brain is herein defined as that in which the meninges covering the brain have been lacerated, directly or indirectly by a foreign body.

Table 1 indicates the mode of injury. Shell fragment wounds were predominant. One hundred and eleven were penetrating and eleven were perforating wounds. It

* Seventeen of these patients were operated upon by visiting officers and therefore are not included in this report.

* From the surgical service of the 8th Evacuation Hospital. This report is a condensation of a paper by the same title read before the Anglo-American Neurosurgical Conference in Florence, Italy, March 20-22, 1945.

TABLE I

Mode of Injury	Patients
Shell fragment.....	96
Gun shot (rifle or m.g.).....	9
Mine.....	7
Bomb.....	3
Grenade.....	2
Other.....	5
Total.....	122

will be noted in Table II that parietal wounds were the most frequent while frontal and temporal were next in frequency. There were fifteen craniofacial wounds.

TABLE II

Location of Wounds	Patients	Incidence, Per Cent	Mortality, Per Cent
Parietal.....	40	32.7	12.5
Frontal.....	22	18.5	15.0
Temporal.....	21	17.2	9.5
Craniofacial.....	15	12.2	0.0
Occipital.....	9	7.3	33.0
Frontoparietal.....	5	4.1	0.0
Temporoparietal.....	4	3.2	0.0
Frontotemporal.....	4	3.2	25.0
Biparietal.....	1	0.8	100.0
Bifronto-parieto-occipital....	1	0.8	0.0
	122	100.0	

MANAGEMENT

Preoperative. Patients were seen in the shock tent by a member of the neurosurgical team. The general condition and prognosis were appraised. If shock was present, as evidenced by the blood pressure or pulse rate, it was first corrected by replacement therapy. This was seldom necessary. More often the patients had considerable mucus, blood, vomitus or bronchial secretion in the throat and every effort was made to clear the respiratory passages by lowering the head and repeated aspiration. When the patient's condition permitted, a brief neurological examination was performed, the wound was examined and he was taken to the x-ray tent for roentgenograms of the skull and any other areas necessary. Stereoscopic views

were not available and usually only AP or PA and a lateral view of the skull were taken. He was then taken to the neurosurgical ward for preoperative care. At least 1,000 cc. of blood was cross-matched prior to operation. Chemotherapy was usually instituted before operation.

The time for operation was not based upon any given time interval, but rather it was deferred until the patient's condition appeared to be optimum. Two factors were of importance in determining the time of operation. First, the condition of the patient as determined by the character of the blood pressure, pulse and respirations and febrile reaction. The second factor was availability of operating facilities, i.e., an anesthetist, operating table, etc. Occasionally, other patients required priority in the operating tent. Fifty-two patients were operated upon less than ten hours after admission. (Fig. 1.) Seventy-one cases reached the hospital less than ten hours after injury. Eighty-nine patients were operated upon less than thirty hours after injury. However, the time interval between wounding and operation was twenty hours or more in seventy-two instances.

TABLE III

Anesthesia	Patients	Per Cent
Endotracheal ether.....	57	46.7
Local field block.....	41	33.6
Local and pentothal.....	18	14.8
Pentothal.....	4	3.3
Open drop ether.....	2	1.6
Total.....	122	100.0

Operative. (a) *Anesthesia:* Anesthesia was almost equally divided between local field block and endotracheal ether. Other coincidental surgery frequently required general anesthesia. Pentothal sodium alone was used only four times but occasionally a craniectomy was done by means of a local field block and then if there were other not too extensive wounds, pentothal sodium was used for the subsequent débridement.

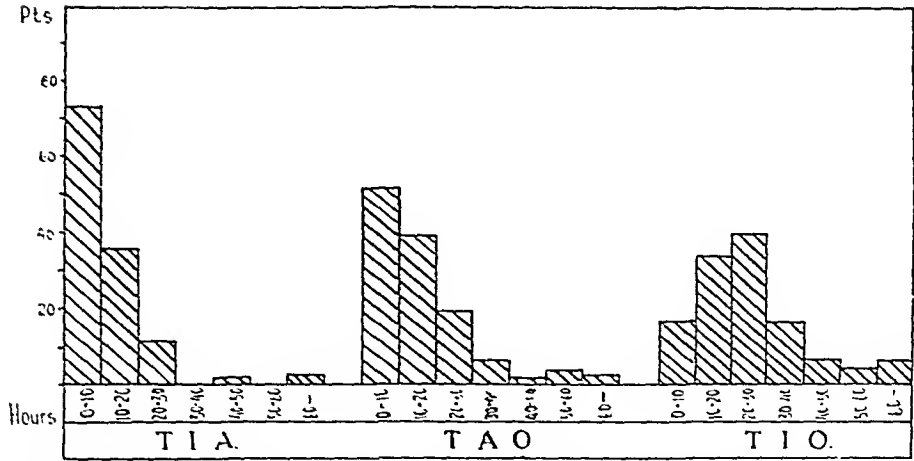


FIG. 1. This chart depicts the relative time intervals from injury to admission, (TIA); admission to operation, (TAO); and the total time interval from injury to operation, (TIO).

The relative use of the various types of anesthesia is listed in Table III.

(b) *Deferred Neurosurgery*: Neurosurgery was deferred for twenty-four to forty-eight hours in fourteen cases in which a craniocerebral injury was complicated by other serious wounds. In one instance, when pneumonia developed after primary surgery, craniectomy was postponed for nineteen days without apparent ill effect. However, in forty-three instances multiple surgical procedures were performed at one operation. The coincidental wounds encountered with penetrating wounds of the brain are shown in Table IV.

TABLE IV

Associated Injuries	Patients	Incidence	Mortality
		Per Cent	Per Cent
Multiple penetrating wounds....	40	32.8	2.5
Major fractures.....	11	9.1	18.1
Thorax.....	4	3.3	25.0
Abdomen.....	1	0.8	0.0
Thoraco-abdominal.....	1	0.8	100.0
Total..	57	46.8	

(c) *Craniectomy vs. Craniotomy*: Craniectomy was the most frequent procedure, having been performed in 111 cases. Craniotomy was reserved for craniofacial wounds and for removing foreign bodies which had traversed the brain. Craniotomy alone was

done only five times. Both craniectomy and craniotomy were performed six times for removal of large, metallic foreign bodies at some distance from the wound of entrance.

(d) *Débridement*: Débridement included the removal of all débris and contaminated tissue from the scalp, cranium, meninges and brain substance insofar as possible. Adequate excision of all contaminated scalp was considered imperative. Concern regarding closure did not influence the extent of débridement. The removal of contaminated bone was likewise as complete as possible. Potentially infected meninges were excised. The débridement of brain substance included removal of all bone fragments, dirt and other foreign matter which could be identified. Débridement of the brain was accomplished by suction removal of soft, devitalized tissue. Bone fragments and metallic foreign bodies were usually removed after visualization. However, gentle palpation with one finger in the wound often identified bone or metallic fragments previously not visualized. No attempt was made to wash devitalized tissue or débris out of the brain wound. Irrigation of the wound was always performed with a cotton pledget in the brain cavity and then only to wash out small, remaining clots of blood.

Metallic foreign bodies were removed when safely accessible. Fifty-eight patients had one or more in the brain. Some were small and inaccessible. Others were fairly

large but had traversed the brain and required contralateral exposure for removal. At first, all these were left to be removed at an installation in the Base Area but later, contralateral craniotomies were done in six instances for removal of these foreign bodies.

(c) *Dural Closure*: The dura was closed in all except four cases. The various manners of closure are listed in Table v. Fifty-six preserved cadaver dura grafts* were employed. After their use was discontinued pericranium was used most frequently. Fascia lata was utilized in eleven patients in whom a large graft was required. In only six instances did suture alone suffice.

TABLE V

Dural Closure	Pts	Postop Abscess	Late Follow-up	Incidence of Abscess, Per Cent	Returned to Service	
					Yes	No
Preserved human dura	46	4	36	13.9	4	4
Autogenous tissue	43	4	26	18.1	4	4
Pericranium	37					
Fascia lata	11					
Temporal fascia	4					
Suture plus muscle	9		3			
Dura open	4		1			
Total	122	10	66		4	4

(f) *Scalp Closure*: The scalp was closed over the cranial defect in all but seven patients. It was possible to close the scalp simply in ninety patients. Thirteen required relaxing incisions and in twelve instances a scalp flap was rotated and a portion of the donor site left open. Primary skin grafts were not done. Tripod incisions

* Employment of preserved cadaver dura was suggested to the authors in November, 1942, by Major (then Captain) Ralph M. Stuck, M.C., A.U.S. It was obtained from any necropsy in which there had not been an intracranial infection, neoplastic disease, acute or chronic systemic infection. The dura was removed and washed in running water to remove all blood clots. The venous sinuses were excised. Only that dura covering the cerebral hemisphere was preserved. After thorough washing, the tissue was placed in 70 per cent ethyl alcohol where it was stored until ready for use. At the operating table it was washed for thirty to forty-five minutes in normal saline solution. The tissue was then cut to overlap, by a narrow margin, the dural defect and anchored in place with four to six sutures.

and closures were avoided wherever possible. Seventy-nine wounds were closed with a small decompressive drain and forty-three were closed without drainage. (Table vi.)

TABLE VI

Wound Closure	Patient	Known Primary Healing	Per Cent	Known Wound Infection	Per Cent
Drain	79	50	63.2	14	17.7
No drain	43	33	74.4	2	4.6
Total	122	83		16	

(g) *Chemotherapy, Local*: Local chemotherapy was employed in forty-nine cases. Sulfanikamide crystals were left in the brain, under and upon the dura in twenty-six instances. Penicillin was used intracerebrally in twenty-three patients. After the latter became available it was used in all cases of ventricular penetration.

(h) *Blood Loss*: Blood loss was replaced as it occurred. Five hundred cc. of citrated, whole blood was always given during operations and occasionally as much as 1,500 cc. was required. Overwhelming or even dangerous hemorrhage was rarely encountered except in injuries of the vascular sinuses or ventricular system.

Postoperative. (a) *Position*: The head of the cot was usually elevated for at least five days after operation. When the patients were unconscious or semi-comatose the foot of the cot was elevated for thirty minute periods to promote tracheobronchial drainage. At the end of these periods the throat was thoroughly aspirated.

(b) *Diet*: Diet was determined by the condition of the patient. If he could eat he was given a full diet and encouraged to eat as soon as possible. Those unable to eat were given parenteral fluids including at least one unit of plasma daily. The remainder of the fluids consisted of 10 per cent dextrose in water to which were added vitamins B and C. Tube feedings were seldom given.

(c) *Chemotherapy, Systemic*: Chemotherapy was continued for at least seven days. Sulfonamides or penicillin was given to all patients. The first thirty patients were given sulfadiazine, by mouth or intravenously, and penicillin was administered to the remaining ninety-two. When pulmonary complications were present or threatening, or when a meningitis developed, sulfadiazine was used to complement penicillin.

(d) *Early Ambulation*: The practice of early ambulation endorsed by the authors in 1943 for patients with cerebral concussion was followed in these cases as well. Patients were allowed out of bed whenever they felt able. A few were ambulatory the first day after operation and many before the fifth. This routine was followed even with those who had wounds of the vascular sinuses.

(e) *Discharge Examination and Evacuation*: Before evacuation to the Base Area patients were given a thorough neurological examination whenever time allowed. In addition postoperative roentgenograms of the skull were made to identify retained foreign bodies, especially bone fragments.

Most of these patients were held for nine or ten days before evacuation. Eighty-four were not evacuated until the ninth postoperative day or later and only five were transferred before the fifth day.

(f) *Follow-up*: Two v-mail forms on which was mimeographed a brief neurological outline with space for other pertinent postoperative data were enclosed with the patient's record as he left the hospital. One copy was returned from the Base Area in the Theater of Operations and the other from the Zone of the Interior. A follow-up was obtained on sixty-five patients.

COMPLICATIONS

Operative. (a) *Vascular Sinus Injuries*: The vascular sinuses were penetrated or perforated in at least nineteen cases. (Table VIII.) Despite the fact that six of

the nineteen patients died, the sinus injury was a contributing factor in only two instances. In both of these the middle third of the superior sagittal sinus had been destroyed, requiring ligation.

(b) *Ventricular Injuries*: Undoubtedly some ventricular wounds were not recognized at operation. Only twelve in this group were known to have had such a complication. (Table VII.) Both bone and metallic foreign bodies were removed from the ventricular system. After it was available, intracerebral penicillin was used routinely in these patients and usually administered intrathecally as well after operation. Brain abscess occurred in three of this group, an incidence of 25 per cent. Intraventricular hemorrhage caused the death of one patient. Six others in this group died but the ventricular injury was not the pertinent factor.

TABLE VII

Complicating Wounds	Patients	Incidence	Infection Per Cent	Mortality Per Cent
Vascular Sinus.....	19	15.5	15.8	31.5
Sagittal.....	13	10.7	....	46.1
Lateral.....	6	4.9	....	0.0
Air Sinus.....	17	13.9	15.4	11.8
Frontal.....	17	13.9		
Ethmoid.....	8	6.6		
Maxillary.....	4	3.3		
Sphenoid.....	3	2.4		
Ventricle.....	12	9.9	25.0	58.7
Lateral.....	12	9.9		
Third.....	2	1.6		

Postoperative. (a) *Cerebral Edema*: During the first nine months of this period concentrated plasma was routinely used twice daily for five days after operation. It had been presumed that this was an effective means of controlling cerebral edema. However, this practice was abandoned in the last fifty cases. No differences were noted in the postoperative course in any respect, including the pulse rate and blood pressure recordings.

Lumbar puncture was used principally as a diagnostic procedure and rarely as a therapeutic aid.

(b) *Convulsions*: Eight patients had convulsive seizures or an incidence of 7 per cent. Only one of the eight had more than one. Three of these were among those who died and the fits were related to extensive brain damage or uremia. Despite the fact that convulsions within the immediate postoperative period are usually of diagnostic importance, only one of the remaining five was known to have required subsequent operation. In that case a brain abscess was recognized but an immediate hospital move necessitated evacuation of the patient.

(c) *Wound Infection-relation to Drainage and Chemotherapy*: Thirteen per cent of these patients were known to have developed wound infections. Eighteen per cent of those wounds drained became infected while only 5 per cent of those closed without drainage are known to have developed infection. (Table vi.)

Eight per cent of those patients in whom sulfanilamide crystals were used locally were known to have developed infection. Of the twenty-three patients in whom penicillin was used intracerebrally 26 per cent were known to have developed subsequent infection. No untoward effects were noted from the local use of either agent.

Sulfadiazine or penicillin was given systemically to all patients. But the presence or absence of infection could be determined in only 104 of the group, the remainder being evacuated or having died before healing had had time to occur. The results were observed in twenty-seven patients who received sulfadiazine. Eleven per cent became infected. The results were observed among seventy-seven patients receiving penicillin. An incidence of 13 per cent infection occurred in the latter group.

(d) *Brain Abscess*: Eleven brain abscesses were known to have developed in this group of patients. This represented 17 per cent of the 65 living patients on whom we had a follow-up. Five of these

TABLE VIII
ANALYSIS OF DEATHS

Patient	Operation	Day of Death	Notes
R. P.	Craniectomy	Po, 10	Hemoglobinuric Nephropathy
J. W.	Bi-parietal craniectomy	Po, 9	Uremia-Sulfadiazine Intoxication
W. Z.	Craniectomy Debridement F.C.C. femur	Po, 2	Irreversible Shock
A. W.	Craniectomy	Po, 1	Hypothalamic Syndrome
M. R.	Craniectomy	Po, 2	Hypothalamic Syndrome
S. S.	Craniectomy	Po, 5	Metallic Foreign Body in Lateral Geniculate Body
F. C.	Craniectomy Thoracotomy	Died on Table	Air Emboli
E. N.	Craniectomy Hip Spica	Po, 2	Fat Emboli
T. P.	Craniectomy	Po, 3	Sagittal Sinus Ligation-Middle Third
L. C.	Craniectomy	Po, 4	Sagittal Sinus Ligation-Middle Third
I. B.	Craniectomy	Died on Table	Carbon Dioxide Intoxication
D. W.	Craniectomy	Po, 1	Post-Lumbar Puncture. Cerebellar and Uncal Herniation at Necropsy
N. W.	Craniectomy Craniotomy	Po, 5	Pneumonia and Lung Abscesses
L. F.	Craniectomy	Po, 3	Overwhelming Cerebral Trauma
H. S.	Craniectomy Trephine for removal MFB	Po, 3	Ventricular Hemorrhage

were diagnosed and operated upon before evacuation and the remainder underwent subsequent operation in a general hospital in the Base Area. Three of the former abscesses contained large, gram-positive bacilli but none resulted in gas gangrene and all recovered after drainage.

Table v also indicates the incidence of abscess in relation to the type of dural graft employed and also denotes the frequency of demonstrable bone fragments in the abscesses. There was essentially the same incidence of abscess among those patients in whom autogenous grafts had been used and those in whom preserved cadaver dura was employed. Bone fragments could

be identified by x-ray or at operation in only half of the abscesses. Metallic foreign bodies retained in the brain were not a contributing factor in any of the known abscesses in this series.

Mortality: One hundred fifty patients with penetrating wounds of the brain reached the hospital alive. One hundred twenty-two were operated upon with fifteen deaths or an operative mortality rate of 12.3 per cent. Some patients who were evacuated died in the next installation to the rear. Six of this group died in a general hospital in the Base Area which is about the usual mortality rate in general hospitals for this type of case. The post-operative deaths are summarized in Table VIII.

SUMMARY

1. One hundred twenty-two patients with penetrating wounds of the brain who underwent primary definitive surgery at an evacuation hospital during fourteen months of the Italian campaign are reported. Less than 2 per cent of battle casualties reaching this evacuation hospital had such an injury. The total mortality rate of all patients with penetrating wounds of the brain who reached the hospital alive was 29 per cent. The operative mortality rate was 12.3 per cent.

2. The factors influencing the decrease in the operative mortality rate during World War II are thought to be chemotherapy, blood replacement and earlier primary definitive care.

3. Aspiration of vomitus, blood or bronchial secretion was a frequent complication. Such a complication required vigorous treatment. Evacuation in the coma position was an aid in preventing aspiration.

4. Surgery upon these patients was deferred until they presented the optimum preoperative condition. Decompression was seldom urgent.

5. Local field block or endotracheal ether were the anesthetics of choice.

6. In general, craniectomy was preferable to craniotomy.

7. Débridement of all involved tissue was considered imperative.

8. Dural closure was preferred in all cases in which a satisfactory débridement of the brain had been accomplished.

9. The tissue used to close a dural defect did not appear to be an important factor in the development of post-traumatic brain abscess. Retained débris or bone fragments were apparently more important factors than the type of graft.

10. Penicillin and sulfadiazine seemed to be about equally efficacious in preventing and controlling infection in cranio-cerebral wounds.

11. Every effort was made to close the scalp over cranial defects. Drainage of scalp wounds would appear to be contraindicated.

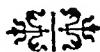
12. Except for injury of the mid-portion of the superior sagittal sinus, vascular injury was not a serious complication.

13. The involvement of air sinuses in craniocerebral wounds was not a serious complication with respect to infection or mortality.

14. Ventricular injury was a serious complication despite the chemotherapy available.

15. The use of concentrated plasma did not objectively alter the postoperative course of these patients.

16. No undesirable effects were noted from early postoperative ambulation.



SURGICAL PROBLEMS IN THE LATE MANAGEMENT OF CRANIOCEREBRAL INJURIES WITH SPECIAL REFERENCE TO THE REPAIR OF CRANIAL DEFECTS WITH TANTALUM PLATE*

AN ANALYSIS OF 170 CASES†

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IN contrast to the circumstance that has heretofore obtained in military medical history, relatively large numbers of patients presenting the late sequelae of craniocerebral injuries have been evacuated during World War II to hospitals in the Zone of the Interior. Statistics bearing reference to the actual numbers of these cases have not been published as yet by the Office of the Surgeon General. The factors that subtend the circumstance are, however, readily recognizable and include the following: (1) High speed evacuation of the injured to surgical installations at which early definitive care is instituted; (2) the exercise of sound neurosurgical principles and meticulous technic by surgeons in the forward zones; and (3) planned chemotherapy, both prophylactic and therapeutic. These three factors have made it possible to preserve life in numerous instances in which the patients heretofore must have succumbed to head injuries and their complications.

It is the purpose of this paper, to set forth the chief problems encountered at a neurosurgical center in the Zone of the Interior, to indicate the modes of their management and to summarize the results insofar as early follow-up permits expression thereof.* The bulk of cases fall

into the following categories: (1) skull defects, (2) infections, (3) intracranial foreign bodies, (4) convulsive seizures, (5) neurological defects (other than convulsions), and (6) the postcerebral concussion syndrome.

SKULL DEFECTS

During the period of two years ending in September, 1945, 170 patients were encountered with defects of sufficient clinical significance to require surgical repair. The defect was principally in the parietal region in fifty-seven of these, in the temporal region in forty-nine, in the frontal region in forty-seven and in the occipital region in seventeen patients. (Table 1.)

By far the commonest original cause of the bony defect was a penetrating head wound followed by débridement. There were 130 such cases. Among the remainder, sixteen were defects as the result of débridement of compound skull fractures and/or depressed fractures of the vault not due to penetrating wounds; six were the result of débridement for osteomyelitis (paranasal sinusitis and hematogenous in origin) of the skull; five were the result of evacuation of subdural hematomas; and three were the result of evacuation

* Psychiatric sequelae as such and neurological sequelae of the sort that fall under the care of the

† From the Neurosurgical Section of the Mayo General Hospital, Galesburg, Illinois. Presented before the Chicago Neurological Society, March 13, 1945, and before the neuropsychiatric conference of the Sixth Service Command, November 17, 1945.

‡ Publication of this paper was aided by a grant from the Ethicon Suture Laboratories, Division of Johnson and Johnson, New Brunswick, N. J.

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ophthalmologic and ear-nose-throat services will not be dealt with here.

TABLE I
THE RELATIONSHIP OF THE LOCATION OF THE SKULL
DEFECT TO THE MOST PROMINENT
NEUROLOGICAL DEFICIT

Neurological Sequelae	Parietal Skull Defect	Frontal Skull Defect	Temporal Skull Defect	Occipital Skull Defect
No clinical sequelae.....	12	23	15	1
Euphoria.....	3	6	0	0
Syndrome of the trephined.....	7	6	11	3
Mild unilateral hemiparesis.....	15	8	8	2
Hemiplegia.....	8	0	6	1
Hemiparesis or aphasia.....	9	4	8	0
Paraplegia.....	1	0	0	0
Tripiegia.....	1	0	0	0
Quadriplegia.....	1	0	0	0
Hemianopsia alone.....	0	0	1	10
Total.....	57	47	49	17

of extradural hematomas. In one instance the defect was due to drainage of a so-called spontaneous brain abscess, and in one case the defect resulted from a subtemporal decompression, the reason for which could not be ascertained because the clinical record had been lost in transit. (Table II.)

TABLE II
THE ETIOLOGICAL AGENTS IN THE PRODUCTION OF THE
SKULL DEFECTS IN THIS SERIES

Dé-bridement of penetrating head wound	Dé-bridement of osteomyelitic areas of the skull	Dé-bridement of compound skull fracture not due to penetrating wound	Evacuation of extradural hematoma	Evacuation of subdural hematoma	Dé-bridement of spontaneous brain abscess	Subtemporal decompression cause undetermined
138	6	16	3	5	1	1

In this series the defect repaired varied in diameter between 2 and 14 cm., the average being approximately 5 cm. In eight patients it was required to deal with more than one defect.

The indications for cranioplasty were considered to be as follows: (1) Pulsating defects anywhere in the vault measuring 3 cm. or more in diameter; (2) disfiguring frontal and frontotemporal defects, irrespective of size; (3) defects unduly sensitive to pressure irrespective of size; (4) defects covered with a thin layer of

scar tissue (such scars were excised at the time of cranioplasty); (5) defects in patients presenting the postconcussion syndrome; (6) defects in patients who complained of a feeling of insecurity because of the presence of a vulnerable area in the head; and (7) defects in patients needing surgical exploration for other reasons (e.g., removal of metallic or bony foreign bodies, resection of meningo-cerebral scar and the uncapping of porencephalic cysts).

By far the most frequent reason for carrying out cranioplasty was the presence of a pulsating defect. The next most frequent reason was cosmetic. A numerical account of the reasons for which cranioplasty appeared to be indicated in the four main regions of the vault (frontal, parietal, temporal and occipital) among the patients in this series is given in Table III.

The material used for repair of the skull defects in all cases of this series was tantalum. This is a non-magnetic, metallic element, the relatively inert chemical and electrical characteristics of which render it highly adaptable to implantation in biological tissues.¹⁻⁵ In plates of .0125 and .015 in. thickness it lends itself readily to molding, cutting and swedging and not its least merit is that contour cranioplasty can be carried out at a single procedure. The only contraindication to its use is the presence of infection. The technical considerations that pertain to the use of tantalum will be dealt with under four headings: (1) The preparation of the plate; (2) a consideration of tissues (scalp, muscle, meninges, brain) in contact with the plate; (3) postoperative fluid collections and their management; and (4) insertion and fixation of the plate at operation.

PREPARATION OF THE PLATE

At the outset, the tantalum plates used in the repair were fashioned at the operating table after the skull defect had been surgically exposed. The technic consisted of first, cutting out a plate, using heavy

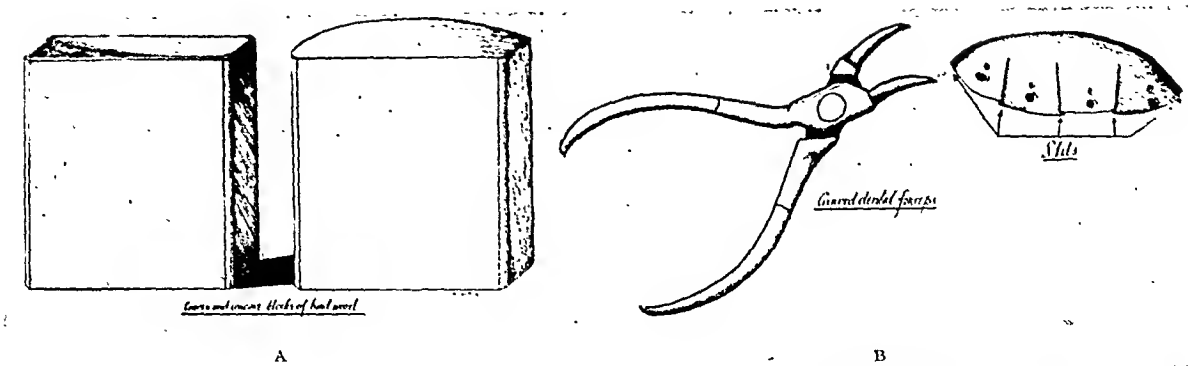


FIG. 1. A, convex and concave blocks of hard wood over which plate may be fashioned by hammering. B, a rapid method of shaping tantalum plate at the operating table.

shears, with all pointed edges of the plate rounded off. Usually the plate was cut to overlap the edges of the defect about 5 mm. Cognizance was then taken of the contour of the skull at that point, following which the plate was beaten out with a mallet, to the required curvature on concave and convex blocks of hard wood. Adequate but not accurate contour could thus be obtained. (Fig. 1A.)

Another more rapid method of shaping the plate at the operating table is that of cutting perpendicular slits about 6 mm. long in the plate, along its periphery at intervals of approximately 1 cm. With a

curved dental forceps, it becomes relatively simple to give adequate curvature to the plate. (Fig. 1B.)

The most obvious disadvantage of both these methods is that unnecessary time is consumed at the operating table in their preparation. Another disadvantage, previously mentioned, is the fact that although the plates are adequate they are not as cosmetically accurate as those which are prepared by swedging the plates from plaster molds. This latter technic is easily mastered and can be used wherever a dental laboratory is available. It consists of six steps:

TABLE III
AN ANALYSIS OF THE REASONS UNDERLYING THE NECESSITY FOR CRANIOPLASTY IN THE VARIOUS PARTS OF THE HEAD

Chief Indications for Repair	Location			
	Parietal	Frontal	Temporal	Occipital
Pulsating defect, 3 cm. or over.....	25	?	30	12
Disfiguring defects.....	7	47	14	3
Skull defect tender to the touch.....	1	There were other indications for repair of many of the frontal defects, but the cosmetic factor was considered sufficiently important in itself	0	0
Thin sear over defect.....	3		0	0
Syndrome of the trephined.....	8		2	1
Surgical exploration necessary for other reasons.....	9 (removal of depressed bone fragments) 3 (removal of shell fragments)		5 (elevation of depressed bone fragments)	1 (removal of foreign body)
Feeling of insecurity, etc.....	2	?	0	0

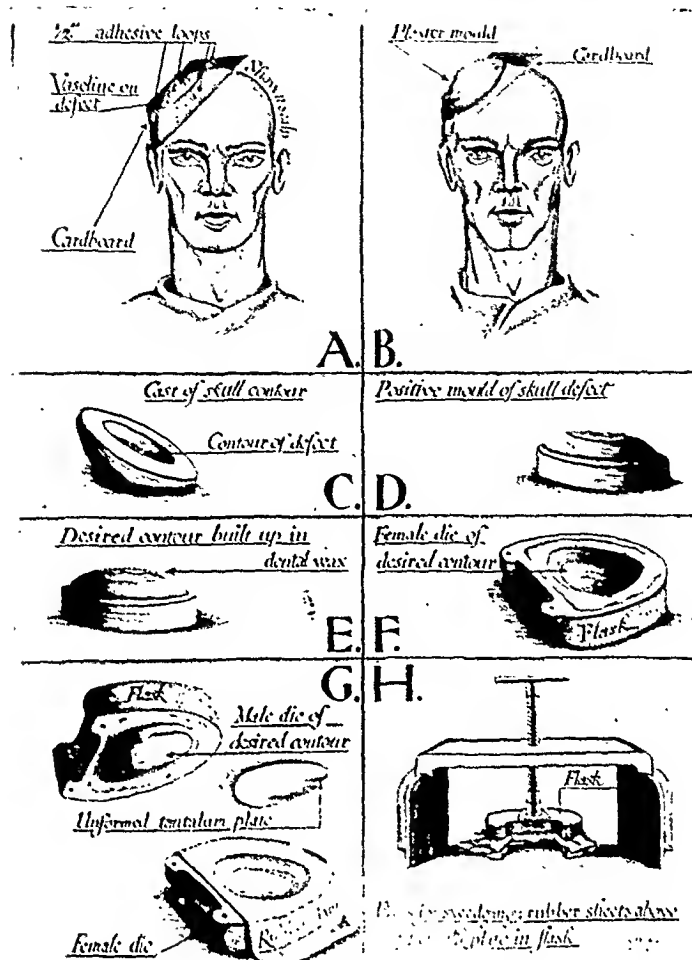


FIG. 2. Illustration of the steps necessary in the preparation of a tantalum plate from a plaster mold of the skull defect.

Step 1. The patient's head is carefully shaved so that the scalp is smooth. The skull defect and an area about three inches around it are then smeared lightly with vaseline and sufficient plaster of paris applied to make a thick negative impression of the skull defect. The plaster is applied over a card board crown which has, affixed to it, small $\frac{1}{2}$ inch adhesive loops which facilitate the sticking of the plaster to the crown. The vaseline facilitates the removal of the plaster cast. (Figs. 2A and B.)

Step 2. A positive impression (Fig. 2D) is then made of the negative cast. (Fig. 2C). This impression is an accurate reproduction of the patient's skull defect.

Step 3. The contours of the normal side of the skull are then carefully studied following which, with dental wax, the defect is filled to correspond accurately with them. (Fig. 2E.)

Step 4. A die of dental stone is then made from this model in a metal flask and when the stone has hardened, a counterdie is poured into the other side of the flask. (Fig. 2F.)

Step 5. The x-rays are studied carefully and the defect palpated through the scalp following which the surgeon marks out on the scalp the amount of overlap desired. This mark is copied accurately on to the prepared die and a piece of tantalum is cut to an approximately 2 mm. greater diameter than this, in order to take up the diameter lost in curving the metal. (Fig. 2G.)

Step 6. The tantalum is covered on both sides by dental rubber dam placed between the die and counterdie, following which in the case of small defects, the plate is swedged by pressure from an ordinary hand press. (Fig. 2H.) If a large plate is being made, a larger, heavier,

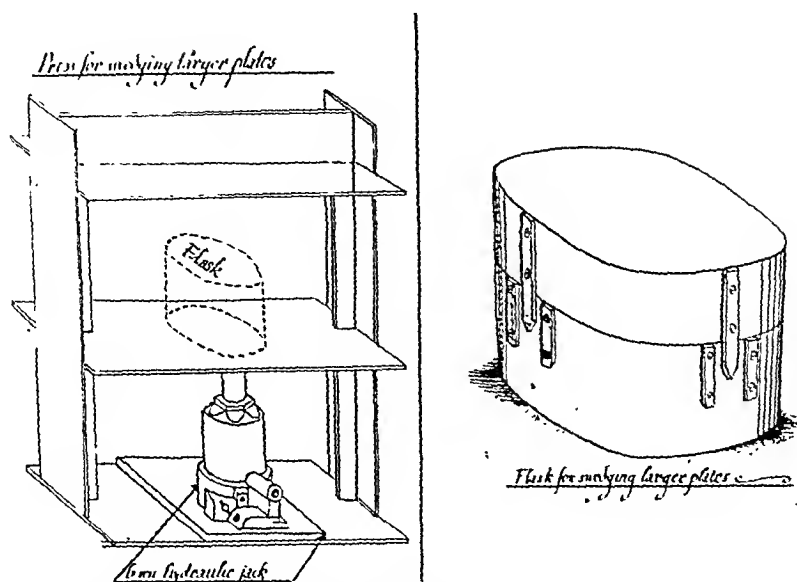


FIG. 3. A schematic representation of the apparatus employed in the swedging of large tantalum plates. The jack underneath the platform may be any type of ordinary automobile jack.

metal container (flask) is necessary for the die and counterdie, with interlocking metal tongues. The pressure apparatus is a simple device composed in effect, of a square of railroad steel bars for counter-pressure and a hydraulic jack capable of six tons of pressure under the platform. (Fig. 3.) It is advisable to scratch directional guides on the surface of the plate, such as A for anterior and corresponding letters for posterior, right and left. This procedure facilitates orientation of the plate during operation.

In the procedure now being employed at this hospital, a number of small holes, 2 mm. in diameter, are drilled in the mid portion of the plate. Although not used by the author, an overhanging ledge about 1 mm. deep around the periphery of the plate is said to increase the strength of the plate.⁶

The temporal muscle renders it almost impossible to obtain an accurate cast of the skull defect when one exists in this region. However, a close approximation can be prepared before operation by swedging, and minor alterations can easily be made at the time of operation by cutting a few slits in the periphery of the plate

and shaping it with curved pliers. (Fig. 1B.) Excellent results may thus be obtained.

CONSIDERATION OF THE TISSUES IN CONTACT WITH THE PLATE

In those cases in which the previous operative scar is not wide and is of adequate length for exposure of the defect, it has appeared advantageous to employ it as the site of incision, since it is less vascular, because it eliminates the necessity of producing another scar, and because it does not further compromise the blood circulation. On the other hand, if the patient's original injury was severe with marked destruction of the scalp and cranium, there is often a wide scar less than a millimeter thick, intimately adherent and largely dependent for its blood supply on the underlying dural or cortical scar. In such cases it is important to remember that death of this scar is inevitable if the tantalum plate is interposed between it and the cortical or dural scar because of insufficient blood supply. No hard and fast rules can be laid down as to the width and thickness of scar which can survive with a tantalum plate underneath it. It has been our experience that solid, relatively avascular



FIG. 4. An illustration of two methods which were used to allow for space taken up by the resection of a very wide scar: A, a relaxing incision made away from the original scalp flap; B, a relaxing incision made by reopening the limb of the flap away from the tantalum plate; both healed well.

scars less than 3 mm. thick and more than 1 cm. square will not generally survive. In such a case, the scar should be excised down to the periosteum. The scalp is then mobilized to take up the space lost. It is essential that the scar be excised fully in order that a full thickness closure through galea and skin may be accomplished. If this is not accomplished, especially if there is slight tension at the suture line, the area over the tantalum will not heal.

It is of interest to note that in three cases in this series in which the scar (for the above reason) broke down over the tantalum, no infection intervened, although the bare tantalum plate was exposed over a period of weeks while conservative therapy in the form of heat, moist dressings and chemotherapy was being attempted.

The most satisfactory exposures were obtained by employing an orthodox scalp flap. Obviously, care must be taken to outline the scalp flap in the vicinity of the old scar so as not to embarrass the circulation.³ Emphasis must be placed once more on the fact that, if a wide scar is present, even though the incision is not

through it, if the tantalum plate lies under it, circulation may be sufficiently embarrassed to cause breakdown of the scar where it is thinnest and obviously nourished from underlying structures. The wisest procedure in our experience has been to resect it first, allow the wound to heal with a little vascular help from underlying structures, and then turn a scalp flap. In those cases in which the scar is of questionable viability, little is lost in turning a scalp flap, inserting a tantalum plate, and waiting to see if it will survive. Here, however, one must be certain to turn a generous flap such that, should the scar break down, it still may be excised from the center of the flap and perhaps one limb of the flap reopened to serve as a relaxing incision. The latter subsequently heals by granulation growth. (Fig. 4B.) Obviously if the bare limb of the flap is over tantalum plate, the area will not fill in. For cosmetic reasons, whenever surgically feasible, incisions should be made beyond the hair line.

On reflecting the flap, or on opening the old scar and retracting the wound edges, the scar in the skull defect is separated from surrounding structures

and overlying galea separated away. If intact dura is present, as much scar as possible is resected from its outer surface. If there is no dura present only as much cerebral scar as presents itself in the skull defect is resected. The x-rays of the skull are studied at the time of operation and if foreign bodies or depression bone fragments are readily available, they may, at the surgeon's discretion, be searched for and removed.

No attempt has been made in this series to repair dural defects except in the three porencephalic cysts repaired. Previous experimental work⁷ indicates that adhesions develop if tantalum foil is placed between the cortex and the arachnoid membrane. Later clinical studies do not substantiate these findings.⁸ In a case which will be described later, it became necessary to remove the tantalum plate four and one-half months after its insertion. The plate was covered with a smooth, almost endothelial-like covering internally and externally. As soon as the holding wires were cut, it lifted easily out of its bed. Careful examination revealed no evidence of adhesions internally or externally. It is believed, therefore, that in the presence of a dural defect, a tantalum plate in the bony defect does not encourage the formation of adhesions between it and the injured cortex.

POSTOPERATIVE FLUID COLLECTIONS AND THEIR MANAGEMENT

Before holes were made in the tantalum plates, 80 per cent of cranioplasties were followed by the development of varying amounts of fluid over the plate. This fluid is serosanguineous in nature and is considered to be in part a reaction to the foreign body and in part, slight postoperative hemorrhage. It was noted in several cases in which dural defects existed that the fluid was high in sugar content. The conclusion was, therefore, that this was in part at least spinal fluid and was due to a temporary upset in its absorption. Aspiration of the fluid twice during a

period of ten days has usually sufficed to control this complication. No untoward occurrences were encountered from aspiration. The potential danger of infection, however, impels the exercise of the strictest aseptic technic in performing aspiration.

Perforation of the plate by permitting a free flow of fluid facilitates its absorption and since this expedient has been adopted there has been a very obvious diminution in the number of patients developing clinically significant quantities of fluid over the plate. This has been previously reported.⁹ The insertion of a rubber drain at operation in the most dependent portion of the wound (removed in twenty hours), and a tight pressure dressing have also materially lessened the formation of fluid over the plate. In borderline cases of scar over the plate where for one reason or another resection of the scar is deemed injudicious, two or three more holes are made in the plate. It is believed that in such cases death of the scar is frequently prevented by permitting the growth of vascular buds through the perforations.

On two occasions the prepared tantalum plate was accidentally dropped during the operation. This entailed a delay while the plate was being resterilized. Such accidents may be precluded by routinely tying the plate to the instrument stand with umbilical tape or heavy black silk until fixation is accomplished.

TECHNICS FOR INSERTION AND FIXATION OF TANTALUM PLATES

Local infiltration with novocaine was employed in every case and no anesthetic difficulties encountered.

Fixation with Screws. (Figs. 5A and 6A.) This is the simplest and most rapid of all the techniques in our experience. Where this type of fixation is decided upon, the plate is previously prepared by placing around its periphery six (or more, depending on the size) holes slightly larger than the diameter of the screw that one intends to use. The skull defect is exposed, the bony margins carefully cleared of periosteum,

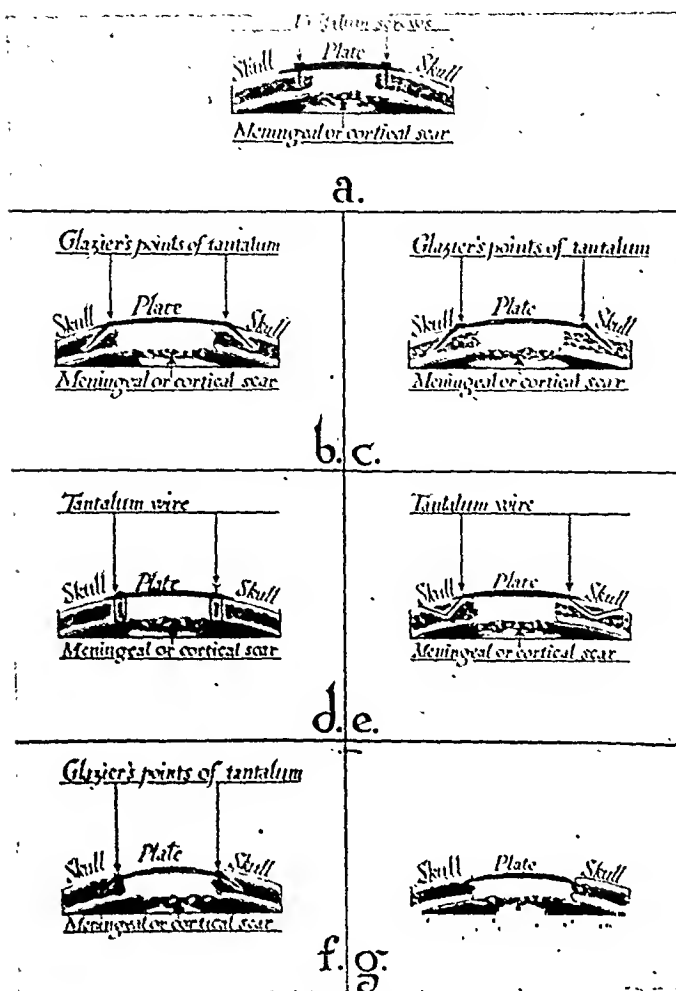


FIG. 5. A schematic cross-section of the different methods used in the insertion and fixation of tantalum plates over skull defects: (a) with screws; (b) glazier's points through the plate; (c) glazier's points over the plate; (d) wire through a full thickness of the skull; (e) wire through a partial thickness of the skull; (f) glazier's points over a counter-sunken plate; (g) counter-sinking of the plate without any other fixation.

and the plate is fitted to the defect, corresponding to the directional scratches. Minor alterations are then made, if necessary, in the shape of the plate. Through selected perforations in the plate, a number of corresponding holes are drilled through the outer table of the skull. The number of screws needed varies, but the maximum that need be used is six for massive plates; two frequently suffice. The criterion is the solidity of the plate. The plate is then removed and the marking holes are drilled to a depth of 3 mm. A pistol drill handle of the Crutchfield type with a perforator guarded at 3 mm. is a rapid method for making these drill holes. It is, of course,

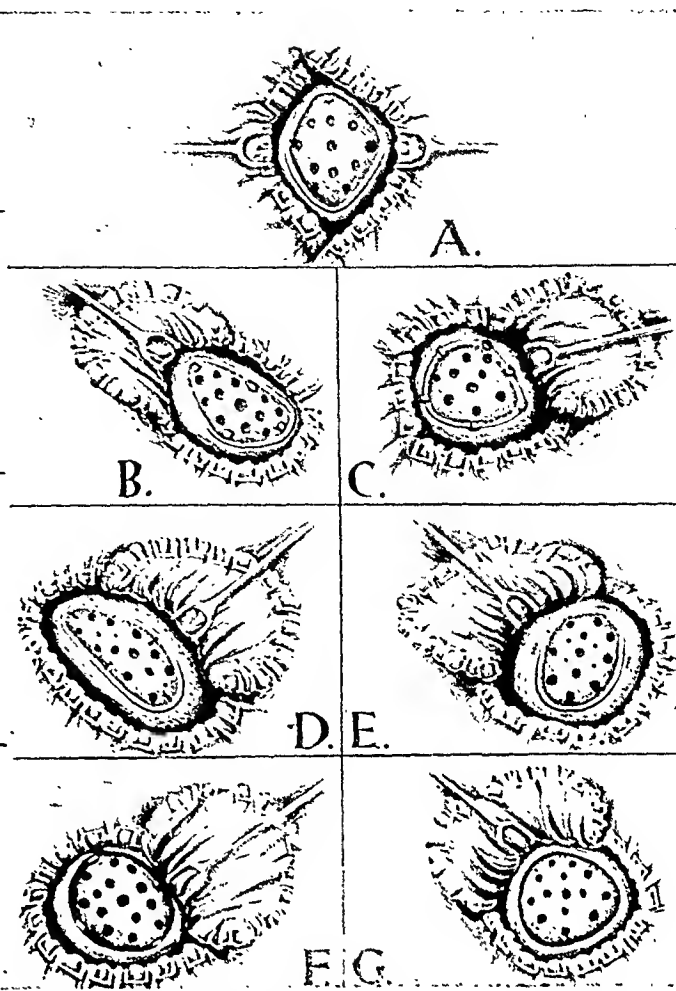


FIG. 6. Artist's sketch of the different methods used in the insertion and fixation of tantalum plates over skull defects: A, with screws; B, glazier's points through the plate; C, glazier's points over the plate; D, wire through a full thickness of the skull; E, wire through a partial thickness of the skull; F, glazier's points over a counter-sunken plate; G, counter-sinking of the plate without any other fixation.

important that the diameter of the drill be slightly smaller than that of the screw. A dental drill with a guard attachment may be employed (Fig. 7) instead of a hand drill. The plate is then replaced accurately over the prepared holes and the screws inserted. A screw holder (Fig. 8B) aids very materially in eliminating the fumbling that goes with the handling of a screw of 3 mm. length.

Certain features of the screw are important. It should be made of tantalum. The head should have a minimum thickness and should be countersunk. The threads should go all the way to the head and the point should be blunted. This technic

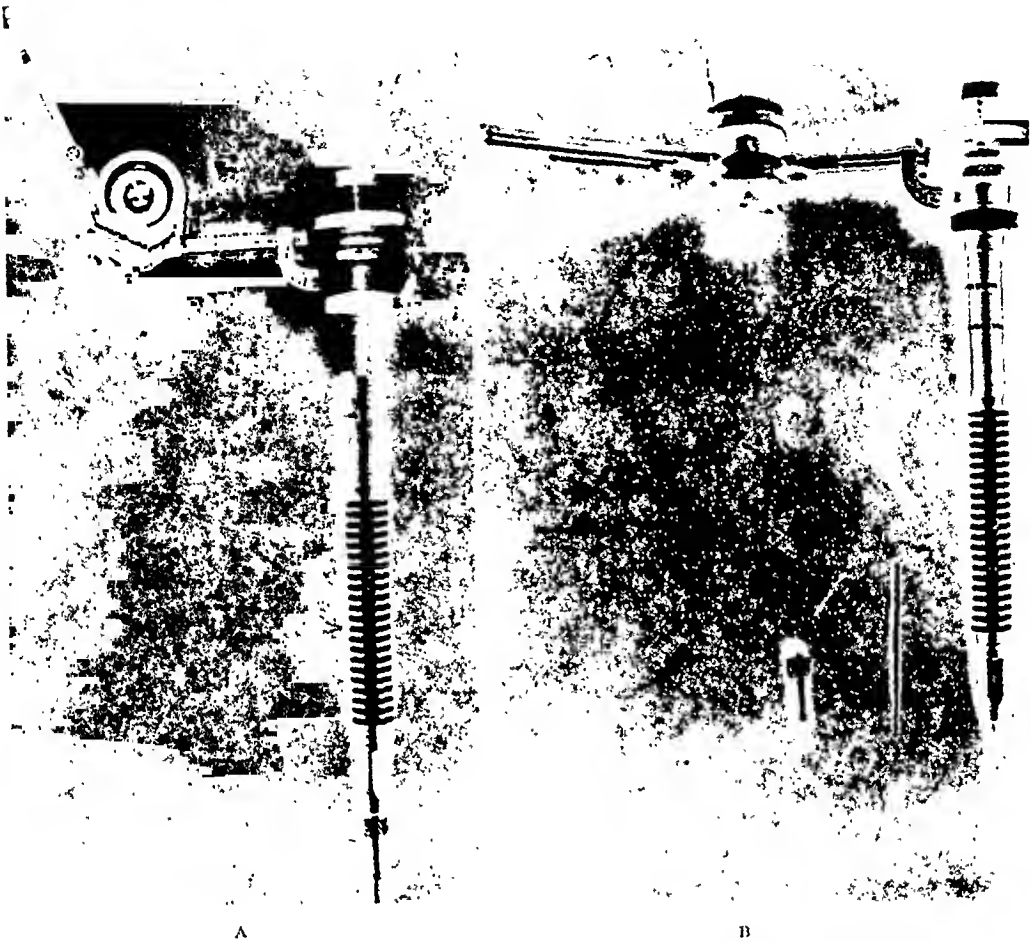


FIG. 7.* A simple method of guarding an electrically-driven dental drill from excessive penetration of the skull. The end of the drill handle is cut off and threaded. A small snout made as illustrated is then threaded on the drill handle. A, set assembled; B, set taken apart.

is not properly applicable where the skull is thin, such as in the temporal region. It is highly desirable where only one border of the plate can be fixed, as in plates over the supraciliary ridge where only the upper border of the plate can be fixed.

Fixation with Wires. (a) Wires through the entire thickness of the skull (Figs. 5D and 6D): For this method the plate must be prepared by making small holes at 1 cm. intervals along the periphery of the plate with a second, matching set of holes $\frac{1}{2}$ cm. within the outer row. Depending on the size of the plate, from three to six wires are used. Strategic points are then chosen, and with the assistant holding

the plate firmly, marking holes in the skull are drilled through the holes in the plate. The plate is then removed. At points opposite the marking holes, the dura is separated from the inner table of the skull. Bleeding is frequently encountered at this point, but is easily controlled with muscle stamps or fibrin foam. With a fine drill, holes are then drilled through the entire thickness of the skull. The accuracy and dispatch of the latter procedure is materially aided, in our experience, by using a fine, electrically driven drill and a Barton drill guide. Where these are not available, the ordinary hand drill with a flat spatula as a guard between the dura and inner table of the skull is used. Here again the guarded dental drill may be employed. Ten cm. lengths of .015 tan-

* Both of these instruments in Figures 7 and 8 were devised under the direction of the author by T/Sgt. William H. Bollinger.

tanium wire are then passed through each hole, the end grasped and pulled up. The wire ends are then passed through the chosen holes in the plate,—the end coming through the defect being directed through the inner series of holes and the end coming through the skull passing through the outer series. In this way an exceedingly close apposition of the plate to the skull is obtained. The wire ends are then grasped with a clamp and the clamp rotated, twisting the wire evenly. A little practice is necessary before one knows just how much twisting the wire will take. The ends of the twisted wire are then cut to a length of $\frac{1}{2}$ cm. following which they are bent flat. The sharp ends are lightly tapped with a mallet to smooth them off, or they may be tucked into their respective holes. This method is ideal for the insertion of a plate in a thin portion of the skull.

(b) Wires through a partial thickness of the skull (Figs. 5E and 6E): For this method, the plate must be prepared by making small drill holes in pairs along its periphery $\frac{1}{2}$ cm. apart. At least six sets should be made. The number of wires inserted again depends on the size of the plate. Marking holes are then made through the pairs of holes in the tantalum plate following which the plate is removed. Diagonal drill holes are then made in a direction away from the defect to about half way between the inner and outer table. Another pair of drill holes, 1 cm. peripheral from the first holes, are then made in such a direction as to strike the first holes. Generally four pairs of such holes are sufficient. A 10 cm. length of .025 tantalum wire is then passed through the holes in such a way as to leave the two loose ends coming out of the peripheral ends of the two bony tunnels. The wire ends are then twisted down as above, cut off at a $\frac{1}{2}$ cm. length and the end lightly tapped into one of the holes. This technic is ideal in regions where the skull is thick, and where for one reason or another, screws cannot be used.

Fixation by Glazier's Point of Tantalum.

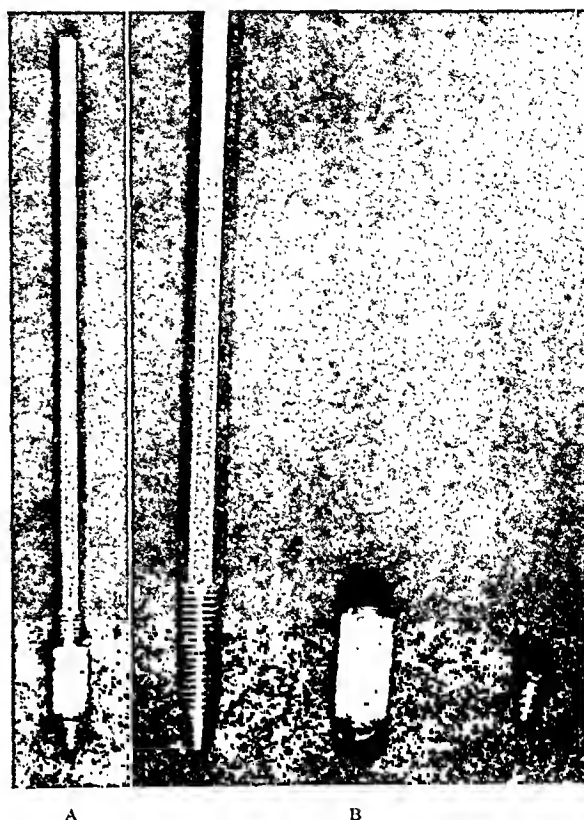


FIG. 8.* A simple screw holder which can be manufactured from the ordinary dental broach holder. A, set assembled; B, set taken apart.

(a) Without countersinking of the plate:
1. With insertion of points through the plate (Figs. 5B and 6B): If this technic is contemplated, five or six slits, 5 mm. long are made near and parallel to the edge of the plate. Glazier's points of tantalum are prepared from trimmings. They should be triangular with a base at least 7 mm. wide and at least 1 cm. long. The assistant holds the plate firmly, and with a small triangular chisel and mallet, a marking hole is made through each slit in the plate. At least four points should be used. The plate is removed and the same chisel used to deepen the holes slightly, the depth varying with the size of the points. These holes should be made at an acute angle and need not go into any appreciable depth. The plate is then reapplied and the glazier's points inserted through the slits, into the holes, and gently tapped in, until they are firmly

* Both of these instruments in Figures 7 and 8 were devised under the direction of the author by T/Sgt. William H. Bollinger.

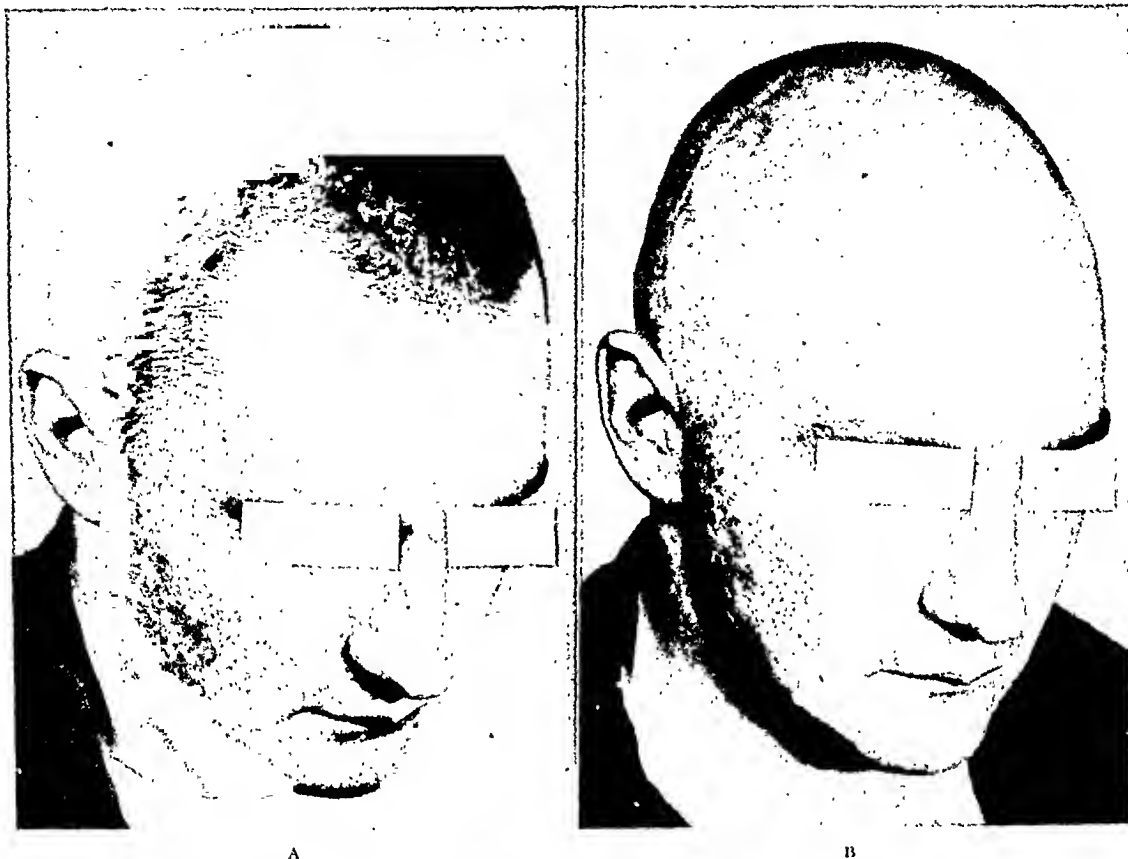


FIG. 9. The pre- and postoperative pictures of a frontal defect repaired with tantalum plate. The incision in this patient was made behind the hair line. The postoperative picture was taken three weeks following repair. A, postoperative; B, preoperative.

"set." By the time they are "set," if the hole has been correctly made, they are lying flush with the plate.

This method is used where the bone is thin and where for one reason or another, screws or wires are not available. In some centers, it is used in preference to screws or wire. One disadvantage is that a good deal of pounding, however gentle, is necessary in the technic.

2. With insertion of points over the plate (Figs. 5c and 6c): This method is exactly similar to the above except that the points are inserted over not through the plate.

(b) With countersinking of the plate (Figs. 5f and 6f): This technic is exactly the same as (a) except that it is not necessary to make slits in the tantalum plate if it is contemplated. It has been previously described.^{2,8} An assistant holds the plate firmly, following which the outline of the plate is cut into the outer table of the

skull with a scribner. The plate is then removed, and with a chisel or gouge, and mallet, a ledge is made to correspond with the shape of the plate. The plate is then replaced and three or four glazier's points inserted as above.

This technic is used in the thicker portions of the skull. It is accurate but time consuming and involves also a good deal of hammering on the skull. It is our opinion that the thickness of the tantalum plate is not such that countersinking is necessary.

Fixation by Countersinking Alone. (Figs. 5g and 6g). This method has been previously described and needs no elaboration.^{2,10} A ledge is made as described in (3b), a shade smaller than the outline left by the scribner. The previously prepared tantalum plate is then gently teased into the ledge. The spring of the metal against the walls of the ledge is often sufficient

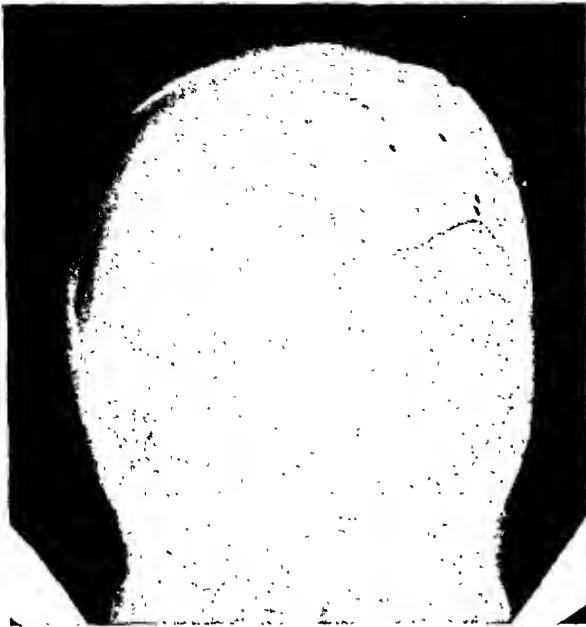


FIG. 10. An illustration of the effective contouring that may be obtained even in large plates by employing the technique of swedging the plate from a plaster cast of the skull defect.

to anchor the plate firmly. This fact is difficult to believe unless the procedure is tried. If the plate is not firm, a few glazier's points are inserted.

Again, this technic involves gentle but comparatively prolonged hammering. It can be employed anywhere in the skull. It is time consuming but accurate.

RESULTS

In this series there were no postoperative infections or deaths. Up to the present, all plates have remained firm. With the current technic, which includes perforation of the plate and drainage for twenty-four hours, the development of fluid overlying the plate has been reduced to a minimum. In only one instance was it necessary to remove the plate because of the persistent accumulation of fluid. This was one of the earlier cases of this series in which the plate was not perforated.

Satisfactory cosmetic results were obtained in each case comparable to that illustrated in Figures 9 and 10. In four cases, thin scalp scars broke down over the tantalum plate. Of these, three were readily repaired by sliding scalp flaps. The fourth proved too large to be dealt



FIG. 11. Lateral x-ray view of two large tantalum plates to illustrate the fact that should an encephalogram be necessary in the future, important details will be hidden by the radiopaque tantalum plate.

with in this manner and required a full thickness skin graft. This was successful.

In those cases in which tenderness of the scar existed prior to cranioplasty, relief was afforded by operation. Two patients who complained of feelings of insecurity because of the defect in the skull were notably relieved following cranioplasty.

A not infrequent complaint among patients with tantalum plates is, that in very cold weather an uncomfortable sensation of cold is felt at the site of the repair. There have been no corresponding complaints in hot weather.

One objection that has been raised to the use of metallic plates (as opposed to plastic materials) in cranioplasty is that, if pneumoencephalography should be in-

licated at a later date, important details may be obscured. (Fig. 11.)

INFECTIONS

In this series of 154 cases of compound fracture of the skull, 126 appeared to have had adequate débridement within three days of injury, and of these only one wound became infected (an instance of brain abscess, later evacuated and healed). Seven patients were not subjected to débridement at all, and of these four (57 per cent) became infected. Nine cases were considered to have been inadequately débrided within the first three days as determined by the demonstrable presence of foreign bodies* and of these six (67

* A difficulty presents in any attempt to decide whether a case was "adequately" or "inadequately" débrided in the echelons of combat or communicating zones. It is entirely possible that in some cases devitalized and potentially infected soft tissues were left *in situ* and that the growth of bacteria was inhibited by the preoperative and postoperative use of sulfur drugs and penicillin. There is obviously no way of identifying the "adequacy" of débridement in such cases. Similarly, results alone cannot fairly be made the measure of "adequacy" of débridement since infections may occur under some conditions in patients quite properly débrided from the surgical standpoint. It seems safe, however, to employ the term "inadequate" when roentgenographic and surgical findings permit the inference that débridement was indeed incomplete.

per cent) developed infections. Table iv sets forth the relations between the time and apparent adequacy of débridement following injury and the incidence of infection.

In twelve cases débridement for one reason or another was postponed beyond three days after the injury. Among these, infection supervened twice, one an instance of osteomyelitis of the vault, the other an instance of extradural abscess. It is of interest that the patient in whom débridement was longest postponed—fourteen days—did not develop an infection. The tabular analysis (Table iv) indicates that while there is in general a significant direct relationship between the time period within which débridement is undertaken and the development of infection, this relationship is not necessarily decisive. Without doubt, the advent of chemotherapy has given to the surgeon a considerable latitude within which débridement is considered mandatory.

In three cases which appeared to have been adequately débrided, osteomyelitis of the skull complicated by extradural abscess developed. The operative record in each case disclosed that free fascial

TABLE IV

THE RELATIONSHIP BETWEEN THE ADEQUACY AND TIME OF DÉBRIDEMENT FOLLOWING INJURY, THE PRESENCE OR ABSENCE OF DURAL TRANSPLANTS AND THE ONSET OF INFECTION

Type of Infection	Adequate Débridement Soon after Injury (less than 3 days)	Inadequate Débridement Soon after Injury (less than 3 days)	Adequate Débridement Late after Injury (4 days to 14 days)	No Débridement	Free Fascia Lata Grafts Inserted at Time of Débridement	Free Temporal Fascia Graft Inserted at Time of Débridement	Sliding Dural Grafts Inserted at Time of Débridement	Tantalum Foil Inserted at Time of Débridement
Simple scalp infection.....	0	2	0	0	0	0	0	0
Osteomyelitis of skull.....	0	1	1	2	0	0	0	0
Extradural abscess with osteomyelitis of skull.....	0	1	1	1	2	1	0	0
Brain abscess.....	1	2	0	1	0	0	0	0
No infection.....	125	3	10	3	6	3	2	2

grafts had been employed to close the dural defect at the original débridement. Two of the grafts were of fascia lata and the third was a free temporal fascia graft. All three sloughed out while under our care. Each was subjected to a new débridement and plastic repair of the scalp with primary closure. In these, as in all infected and potentially infected cases of this series, penicillin was administered intramuscularly in 110,000 unit doses each day for seven days beginning on the day of operation. The value of penicillin in the treatment of osteomyelitis of the skull has already been described.¹¹ Tantalum plates were inserted approximately one month after the scalp closure. In each case healing proceeded without untoward occurrence.

The data at hand suggest a considerable likelihood that infection will develop if free grafts are employed to accomplish dural closure at the time of first débridement. Even though full allowance be made for the fact of their autogenicity, such grafts, inasmuch as they possess no blood supply, constitute in effect foreign bodies. As such, they favor the growth of bacterial organisms which might well succumb to

immunologic and chemotherapeutic control were there no foreign body present. Acknowledgment must be made of the general soundness of the surgical principle that dictates anatomical closure of tissues. Nevertheless, the necessity of closing the dura seems to have been overemphasized. It does not appear defensible to give the principle of layer-by-layer closure precedence over the equally well established surgical principle of scrupulous avoidance of foreign bodies in potentially infected wounds.

In addition to the three cases referred to above, we encountered seven other instances of osteomyelitis of the skull, three of which were also complicated by extradural abscess. (Table v.) In each of these cases, treatment consisted of wide resection of the involved bone and the maintenance of open drainage until the area became cicatrized. Approximately a month later the scar was resected and a tantalum plate inserted. In all, healing proceeded without complication. In cases of chronic osteomyelitis of the skull, as in the fresh cases of open cranio cerebral wounds, the advent of chemotherapy has made possible an active

TABLE V

THE RELATIONSHIP OF THE DEGREE OF BRAIN INJURY TO THE ONSET OF SEIZURES AND OF INFECTION

Degree of Cranio cerebral Injury	Seizures Immediately Following Cranioplasty without Late Recurrence	Seizures Immediately Following Cranioplasty with Late Recurrence	Seizures before Cranioplasty without Postoperative Recurrence	Late Onset of Seizures Following Cranioplasty	Simple Scalp Infection	Brain Abscess	Osteomyelitis of the Skull	Extradural Abscess with Osteomyelitis
Without dural or brain laceration.....	0	0	0	0	2	0	1	5
With dural laceration but without brain injury.....	2 generalized 1 Jacksonian	0 5 Jacksonian 2 generalized	0 6 Jacksonian 1 generalized	0 8 Jacksonian 1 generalized	0 0	0 3	1 1	1 0
With dural and brain laceration.								
Findings at initial débridement unknown	1 Jacksonian 2 generalized	1 Jacksonian 1 generalized	0	4 generalized	0	1	1	0

attack on a surgical problem of a difficult sort, which, until very recently, demanded caution and extreme conservatism.

In two of our patients, infection was confined to the scalp. Moist dressings were employed for four weeks without salutary effect. The indolent area was then resected and the scalp closed anatomically with silk. The wounds in each case healed without drainage. Approximately one month later tantalum plates were inserted. The postoperative course in these patients was uneventful.

In four instances, compound fractures of the vault were complicated by the development of brain abscess. Three of these were healed by surgical marsupialization in combination with chemotherapy. In each case tantalum plates were inserted approximately three months after the completion of epithelialization. The fourth case was admitted in extremis. Some seven weeks prior to admission he had sustained a severe bifrontal compound comminuted fracture with massive damage to frontal lobe tissue. The wound had not been débrided. Shortly following admission, open drainage of the abscess was instituted but death occurred on the third postoperative day. Autopsy disclosed a second brain abscess 4 cm. lateral to that which had been surgically drained.

INTRACRANIAL FOREIGN BODIES

Among the 170 cases of this series foreign bodies were removed from thirty eight (22.3 per cent). Approximately four-fifths of these were bony and with one exception (a piece of helmet liner) the remainder were metallic fragments.

The following were considered indications for the removal of foreign bodies (Table III): (1) The presence in infected areas of metallic fragments, sequestra or indriven bone fragments; (2) the presence of foreign bodies considered as the likely cause of or favoring the persistence of neurological dysfunctions; and (3) the relative accessibility, without entailing undue cerebral damage of foreign bodies

in the operative fields of patients undergoing cranioplasty.

It was considered unwarranted to attempt the removal of a foreign body deeply embedded in the brain, not regarded as responsible for neurologic disturbances or likely to produce infection.

In fifteen instances operation was performed chiefly from the necessity of removing fragments from the region of the skull defect. In each of these tantalum cranioplasty was carried out at the same operation. In no case did untoward complications appear.

From twenty-three patients subjected to operation chiefly for cranioplasty, metallic and bony fragments were incidentally removed.

It is difficult to determine whether in those cases presenting focal neurological disturbances the removal of foreign bodies was a significant factor in their subsequent clinical improvement. Our impression is that valid estimates along this line could not be drawn for the reason that in most cases considerable time elapsed between the surgical procedure and the first appearance of improvement,—a period during which it is conceivable that concurrent reparative processes and other factors (e.g., vicarious functioning and re-education) were at work.

In only one case did it become necessary to apprehend the foreign body through a bone flap away from the site at which the missile penetrated the skull. In this patient, a large metallic fragment had lodged in the anterior vermis just under the tentorium. (Fig. 12.) Incapacitating dizziness was the patient's most conspicuous neurological symptom. A small occipital bone flap was reflected and, through an incision in the tentorium, the fragment was removed, affording prompt relief from dizziness.

CONVULSIVE SEIZURES

For raw statistical purposes, all patients who displayed the phenomenon of recurring explosions of tonic or clonic contractions, whether mild, moderate or severe and

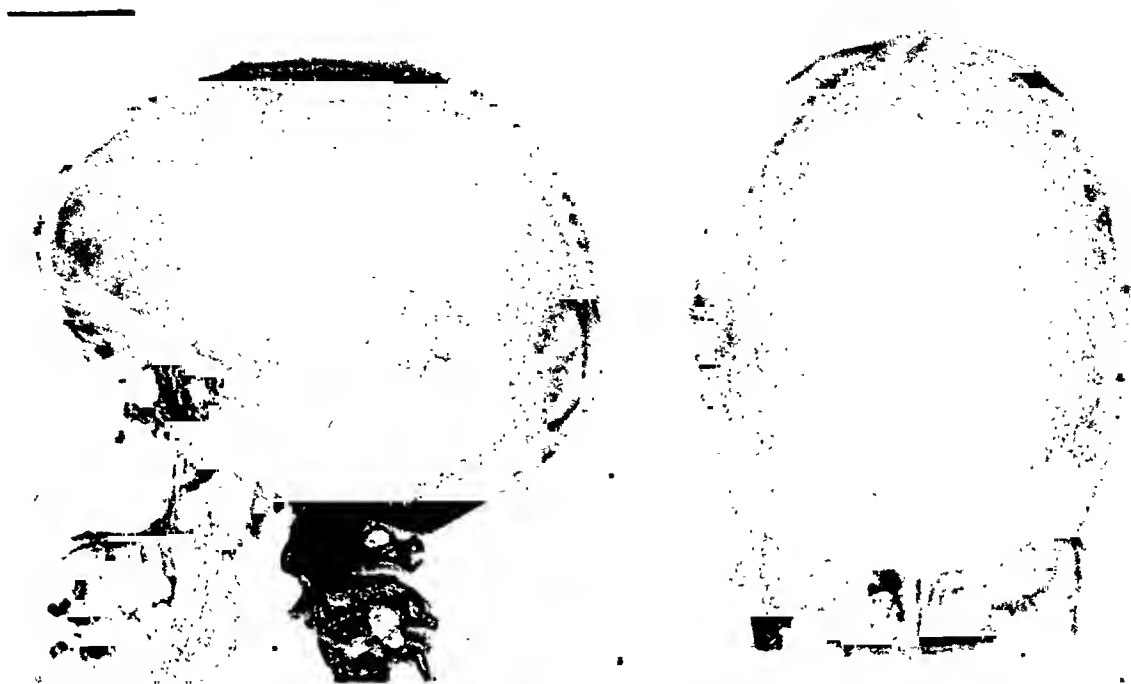


FIG. 12. Roentgenograms of the skull revealing a sub-tentorial shell fragment, the removal of which necessitated an approach, (away from the wound of entrance) through an occipital bone flap, and through an incision in the tentorium cerebelli. Immediately following operation, there was almost complete recovery from previous incapacitating dizziness.

whether or not attended by loss of consciousness were included in the convulsive seizure group. Thirty-five patients (20.6 per cent of the series) fell into this group. (Table v.)

Our present figures must be regarded as tentative and it is likely that they will increase as the follow-up period progresses during the next decade. Our oldest cases have been followed for a little over two years and the most recent for but two months. Before being separated from military service, all our patients who have had serious craniocerebral trauma are instructed to report upon seizures when and if they occur. It is safe to assume that not all patients may be relied upon to so report. The inevitable consequence of this will be that statistical data, properly cleared, will undershoot the mark, and some allowance will, therefore, have to be made for this when comparative studies on post-traumatic epilepsy appear in the literature.

In twenty-two of our patients the pattern of attack chiefly observed was of the jacksonian variety. In thirteen others the most characteristic attack was of the

"grand mal" type. We have regarded the differences between jacksonian and grand mal patterns as merely clinical description indicative only of the probable locus of an epileptogenous "firing point" rather than as significant for etiologic, pathologic or other qualitative differences.^{12,13} That more than one "firing point" may exist in any given case seems a substantial concept.

In seven cases, convulsive seizures had developed before surgical repair was carried out at this hospital; in fifteen the first (known) attack developed within two weeks of operation; and in thirteen seizures did not make their appearance until five to fourteen months after cranioplasty. Each of these three groups will be separately considered from the gross pathologic and therapeutic standpoints. (Table v.)

All seven patients whose seizures were established prior to cranioplasty had meningocerebral scars, the result of laceration of the dura and adjacent brain. Porencephalic cysts were present in three of these, among which was one patient in whom a piece of tantalum foil had been used at the original débridement to bridge a large dural defect. The tantalum had

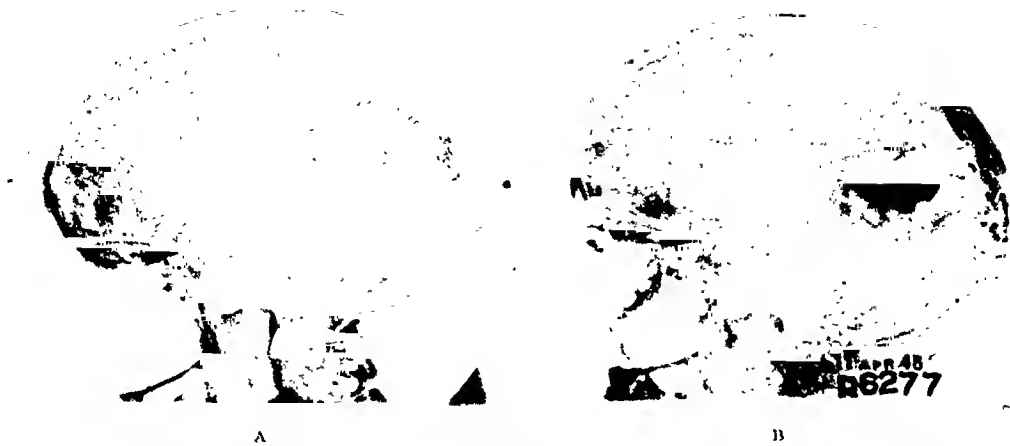


FIG. 13. A, an illustration of the use of tantalum foil as a dural substitute. This soldier had a very severe meningocerebral laceration. The wound was débrided overseas and the tantalum foil inserted to act as a dural substitute. At the time of cranioplasty the tantalum foil was found buried in a mass of heavy meningocerebral scar. B, a lateral pneumoencephalogram of the same patient described in A. The large porencephalic cyst was uncapped and the meningocerebral scar resected. No seizures were reported postoperatively (thirteen months).

become fragmented (Fig. 12) and was found buried in the cerebral scar overlying the cyst. All of these patients were medicated with barbiturates, beginning on the day of operation and continuing for a period of approximately eight weeks thereafter. In all but one of these patients no recurrence of seizure was reported. In this patient a seizure occurred during the fifth postoperative month. Phenobarbital was resumed and up to the present no seizures have been reported. Cranioplastic repair was carried out on these seven patients. The porencephalic cysts were uncapped incidental to cranioplasty and their corresponding dural defects were closed with fascia lata grafts. Among the remaining four patients, two presented intact duras (their defects having been repaired at the time of the original débridement) and two had defect of the dura. In each of the latter cases, the cortical scars were resected but no attempt was made to repair the dura.

There were fifteen patients whose seizures first appeared within two weeks of cranioplasty. In six of these only one to two seizures occurred and, up to the present, no recurrences have been reported. Of this group of six, four patients revealed an intact dura at the cranioplastic

procedurc. The other two presented dural defects and in one of these a cerebral scar of sufficient extent and density to warrant excision was exposed. The remaining nine patients continued to have seizures for several months, and three of them still report occasional attacks. At operation two of these presented dural defects and seven appeared to have an intact dura. In the former the cerebral scars were resected but no dural repair was attempted; in the latter no surgical treatment other than repair of the cranial defect was carried out. Barbiturates have been regularly prescribed for those patients with recurrent attacks.

There were thirteen patients whose first seizures came late after the repair of the skull defect. The earliest of these appeared five months and the latest fourteen months following cranioplasty. Among these, ten had had, at the time of injury, lacerations of the dura which had been repaired at débridement. The remaining three presented the late evidences of unrepaired dural defects and meningocerebral scars. In the former, nothing surgical was done other than the repair of skull defects; in the latter, the meningocerebral scar was resected but no attempt at dural repair was made. As in the previous



FIG. 14. Color photographs of a skull defect with an intact but somewhat scarred dura before and after the insertion and fixation of a tantalum plate using screws.

group, all of these seizures have been controlled by the use of barbiturates.

In reviewing the series as a whole there is general agreement with the experiences of Wagstaffe, Penfield and Erickson,¹⁵ and Penfield,¹⁶ that the incidence of seizures in patients in whom the dura and brain were lacerated at the time of injury is higher than in those in whom these structures are not so damaged. Other writers have reported a higher incidence of post-traumatic epilepsy (Schürer-Waldheim¹⁷ 25 per cent, Baumm¹⁸ 44 per cent). In our series it happens that seizures were not recorded in patients in whom, so far as could be judged, the dura and the brain had not been lacerated; on the other hand in all patients with convulsions there was evidence that the dura and brain had been lacerated at the time of injury. The significance of these figures is somewhat diminished when it is recognized that the vast majority of patients in this series, for the very obvious reason that they required cranioplasty must have had lacerations of the meninges and brain. Similarly, a lacerated cortex might well have been hidden from view by an intact dura. That 20 per cent of our patients developed seizures, all of whom lacerations of the dura and brain is somewhat offset by the complementary observation that in the great bulk of our cases without convulsions the dura and brain were lacerated.

Among the 154 cases of compound fractures of the skull in this series there were forty-one patients in whom the dura was not repaired at the time of débridement and in whom the skull defect was occupied by galeal and meningocerebral scar. Of these eleven (25 per cent) developed seizures at one time or another. Among the remaining 113 patients there were twenty-three (21 per cent) in whom the dura was repaired at the time of débridement and who developed seizures. There is, therefore, in this series no evidence that repair of the dura mater at the time of original débridement is a significant factor in the prevention of post-

traumatic epilepsy. Furthermore as seen from the tabular analysis (Table VI) there is little or no evidence to indicate that repair of the dura some months following injury precludes the onset of seizures.

TABLE VI
ANALYSIS OF THE INFLUENCE OF DURAL REPAIR AT THE
TIME OF CRANIOPLASTY ON THE DEVELOPMENT
OF SEIZURES

Condition of Dura	Onset of Seizures Immediately Post-operative without Late Recurrence	Onset of Seizures Immediately Post-operative with Late Recurrence	Late Onset of Seizures Following Repair	No Seizures
Dura intact....	4	8	10	91
Dural defect not repaired at cranioplasty..	1	2	3	35
Total.....	5	10	13	126

In this group of cases resection of meningocerebral scar was carried out only where the scar presented itself in the skull defect and in the three porencephalic cysts already referred to. It does not appear indicated routinely to resect every meningocerebral scar encountered at the time of cranioplasty. It seems preferable to resect this scar only when it is easily available and when its removal is not likely to further impair cerebral function. If the scar is not readily accessible and if seizures have not occurred, cranioplasty alone appears indicated; if clinically indicated, resection of the meningocerebral scar can be performed at a later date.

There is no evidence from our observations that tantalum cranioplasty has an influence on the development of post-traumatic seizures.

NEUROLOGICAL SEQUELAE (OTHER THAN CONVULSIONS)

Among the 170 patients, fifty-one presented no clinical neurological disturbances at the time they came under our care, five weeks to five months following injury.

The remaining 19 patients showed various aberrations of both focal and general character. No attempt has been made to itemize all disturbances encountered in each patient. The tabular analysis (Table 1) confines itself to a consideration of the most conspicuous neurological sign or symptom encountered in a given patient. By far, the commonest disturbance was hemiplegia of which there were thirty-six cases. Closely allied to these and differing from them in degree only were the thirty-three patients with hemiparesis. As would be expected from anatomical considerations, 78 per cent of these were subtended by injuries of the temporoparietal regions of the vault. The second commonest neurological sequel was the post-traumatic syndrome, the separate symptoms of which are listed elsewhere in this communication. There were twenty-seven such cases. The third commonest disturbance was aphasia of which there were twenty-one instances. All of these were associated with hemiplegia of varying degree. Eleven patients presented hemianopsia. The remaining disturbances were few in number and of varied character. (Table 1.)

In forty-three instances differential diagnosis was not resolvable by clinical study alone, and in these cases pneumoencephalography was employed. It was incidental to this procedure that three porencephalic cysts were disclosed. It is clear that the mode of operation in these three patients was very appreciably influenced by the information obtained from the air studies.

Among the hemiplegic and aphasic there was in general a tendency toward spontaneous improvement. All but one of the hemiplegics improved sufficiently to walk unaided. The vast majority of them were ultimately able to dispense with a cane. Similarly all the aphasic patients except one regained a sufficient vocabulary to be able to communicate their common needs. In many, a near-normal speech function was regained. The single patient who did not appear to improve during a period of observation of eighteen months

had profound destruction of the left temporoparietal lobe.

It cannot be asserted with any certainty that the surgical procedures employed in these patients, which included removal of foreign bodies, resection of meningocerebral scars and repair of skull defects exerted any salutary effect on the recorded clinical course. Measures carried out over a sufficient period of time directed at the general psychological improvement of the patient including physical therapy, speech training, reconditioning and occupational therapy are all important determinants of the end result.

POSTCEREBRAL CONCUSSION SYNDROME

This syndrome, otherwise known as the post-traumatic syndrome and the syndrome of the trephined, is commonly considered to include headaches, dizziness, insomnia, asthenia, fatigability, nausea, deficiency of attention and tinnitus. Only three of the twenty-seven patients complaining of these symptoms presented focal neurological signs,—two had hemiparesis and one had homonymous hemianopsia. With three exceptions the patients who developed the syndrome were unconscious for twenty-four hours or less; ten were unconscious for less than three hours. This analysis points to the fact that the post-traumatic syndrome is, in general, most likely to occur in the milder group of craniocerebral injuries. It is of interest to note that there was no correlation between the size of the bone defect and onset or severity of the post-traumatic syndrome.

Of the twenty-seven patients complaining of these symptoms, twenty-three had complete relief, two had partial relief and two had no change in their symptoms following cranioplasty.

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ACUTE traumatic cerebral compression is due chiefly to hemorrhage from a fracture involving the squamous plate of the temporal bone. In 90 per cent of the cases the bleeding occurs from the anterior branch of the middle meningeal artery; in 10 per cent from the posterior branch.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

PAINFUL INJURIES OF NERVES AND THEIR SURGICAL TREATMENT*

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INTEREST was first focused on the elusive problems of pain after wounds of the peripheral nerves by the classical description of Mitchell, Morehouse, and Keen³⁵ in a book based on their experience with these distressing injuries during the war between the States. After such a promising early start, it is surprising that more was not found out about these lesions during the periods of peace and recurrent wars which led up to the recent conflict. During and after the first World War the pioneer work of Leriche²⁵ has been a constant stimulus. The solution of how to relieve most of these sufferers by neurosurgical intervention has evolved gradually and finally been put on a fairly satisfactory basis by the combined work of American and British military surgeons during the war just finished. With the great number of amputations and injuries of peripheral nerves which have reached our base hospitals from overseas, these sources of persistent pain are certain to be a major reconstruction problem for years to come.

UNDERLYING PATHOLOGICAL FACTORS

The common injuries which may lead to persistent pain are amputations and partial or complete wounds of the peripheral nerve trunks. Concomitant injury of a large artery may also occur, but as this complication is not present in the majority of cases it cannot play any important rôle. Faulty regeneration of injured nerves, sepsis, and resultant formation of scar tissue appear to constitute the underlying factors which give rise to painful stimuli, although some further factor is necessary

to explain the onset of burning pain in the hand or foot which sometimes develops within a few hours after the wound. Wilfred Trotter⁴⁵ in his classical essay on "The Insulation of the Nervous System" pointed out that all regenerating sensory axones "resemble pain fibres in a lack of complete insulation. It is probable, therefore, that imperfect insulation tends to render all fibres less sensitive than normal, but more apt . . . to respond in an exaggerated explosive way." Recent determinations of the threshold for "burning" as contrasted with "pricking" pain performed by Bigelow, Harrison, Goodell, and Wolff³ have demonstrated that the slowly conducting, poorly myelinated "C" fibers carry these disagreeable forms of sensation. The "paradoxical pain" of the peripheral neuropathies is the expression of a defect in the nerve in which the threshold for "burning pain" is depressed, so that ordinary innocuous stimuli are perceived as painful, whereas the threshold for "pricking pain" in the larger myelinated fibers is elevated. Another theory based on partial injury of sensory axones has been put forward by Foerster (Bumke and Foerster⁵). This assumes that the larger myelinated sensory fibers which enter the posterior columns of the spinal cord exercise an inhibitor action on the smaller pain fibers, so that an exaggerated painful response (hyperpathia) may result after a partial nerve injury in which a majority of the former axones have been destroyed.

Another likely factor in the production of pain is anoxia, either from local scarring or from widespread vasoconstriction. In recent

* From the U. S. Naval Hospital, St. Albans, N. Y., and the Neurosurgical Service of the Massachusetts General Hospital, Boston. This article has been released for publication by the Division of Publications of the Bureau of Medicine and Surgery of the United States Navy. The opinions and views set forth are those of the writer and are not to be construed as reflecting the policies of the Navy Department.

experiments Lorente de Nó²⁹ has shown that a nerve made anoxic fires off repetitive stimuli, which suggests that impaired circulation may be a fundamental source of painful stimulation. Still another possible explanation is an accumulation of painful metabolites in the neuroma, and the failure of the impaired circulation to wash them away. Neuromas combine the two essentials of naked nerve endings in a mass of poorly vascularized scar tissue. Amputations and wounds of nerves near the periphery of a limb are most likely to set up persistent painful states because of the greater number of nerve endings and the greater intensity of the vasomotor discharge in these areas. The incidence of painful complications is particularly high in emotionally unstable individuals with superimposed vasomotor disorders.

In addition to the possible rôles of vasospasm and local ischemia in the production of these painful states, Doupe, Cullen, and Chance¹¹ have suggested another factor associated with overactivity of the sympathetic nervous system. They ascribe the peculiar qualities of causalgic pain to direct cross stimulation of sensory fibers by efferent sympathetic impulses at the point where the nerve trunk is injured, rather than to the indirect action of the vasoconstrictor response which they also produce. This theory deserves serious consideration, as in certain stages of the evolution of many of these painful syndromes there may be an actual vasodilatation. Doupe and his co-workers have cited most convincing evidence for this activation of sensory fibers by sympathetic impulses. Their theory furnishes an explanation not only for the increase in pain which so characteristically takes place in a cold environment, but also for that occurring during any form of emotional excitement, cutaneous stimulation, and, in some extreme instances, during everyday visual and auditory stimuli. Burning pain in causalgia and in certain other conditions occurs in direct relationship to the tonic vasomotor, sudomotor, and pilomotor discharge over the

sympathetic efferent pathways. It is reduced in a quiet, stable environment and during sleep, when the tonic hypothalamic discharge is greatly diminished. There is no valid evidence that the sympathetic system plays any direct rôle in the central conduction of the painful stimuli.

As further corroboration of this theory of sympathetic activation of sensory fibers, it has been shown by Katz and Schmitt²⁴ that under certain circumstances efferent nerve impulses can alter the excitability of adjacent sensory axones. Recently Granit, Leksell, and Skoglund¹⁵ have given direct experimental proof of such cross-stimulation between motor and sensory fibers at a point of nerve injury by recording with the cathode ray oscillograph an afferent discharge from the sensory root which takes place when the motor root is stimulated. They conclude that the small, poorly myelinated pain axones of the C-group should be especially susceptible to "fiber interaction," and that this is a simple explanation for some of the symptoms of causalgia. The theory of Doupe and his co-workers assumes that the activating impulses come from the sympathetic vasomotor, pilomotor and sudomotor discharge, which is always increased by cold or emotional excitement.

TYPES OF PAIN

Painful Neuromas. End bulb neuromas, which can often be palpated in an amputation stump or scar over an injured nerve, can produce exquisite local tenderness and, in addition, cause ill defined disagreeable sensations over wide areas. Although the local tenderness may be relieved by resection of the end bulb and effective measures to prevent its reformation, various forms of pain may persist—phantom sensations in the missing extremity, burning hyperesthesia, deep aching sensations with central radiation, and at times crises of lancinating pain. Why most neuromas should be painless and others the cause of long-lasting torture is quite unknown. This cannot be explained entirely on the basis of

any idiosyncrasy on the part of the individual patient (such as a low threshold for pain), because in certain individuals with multiple nerve injuries or amputations only a single neuroma will become painful (Livingston²⁸). Why is removing the pain-producing neuroma so seldom successful? A new neuroma may form, but sometimes the pain is not even temporarily relieved or recurs sooner than the peculiar end bulb can be reproduced. This and the fact that more proximal crushing or chemical destruction by infiltrating the nerve trunk with alcohol fails to give relief has forced investigators to predicate a central extension of the pain mechanism. Mitchell, Morehouse, and Keen³⁵ described an ascending neuritis, but numerous examinations of sections of nerves removed during therapeutic neurectomies have failed to show evidence of any histologic alteration. It is, therefore, far more likely that the central disturbance is due to abnormal spinal reflex or cortical activity, as has been suggested by Livingston²⁸ and by Doupe et al.¹¹

Causalgia. The classical causalgic syndrome, described by Mitchell, Morehouse, and Keen,³⁵ is most often seen after partial injuries of the ulnar, median, and sciatic nerves. (Fig. 1B.) While subsequent sepsis and excessive scar tissue reaction may at times constitute predisposing factors, the characteristic pain often appears within a few minutes or hours of the receipt of the wound. (Table III.) A peculiar burning and tingling hyperpathia* involves the hand or foot and is most pronounced in the digits, palm of the hand, or sole of the foot. With complete immobility from pain, the skin soon becomes shiny and glossy smooth, at times scaly and discolored (Fig. 1A), with tapering fingers and long curved nails. The painful area is frequently not restricted to the area of sensory defect, but this is often difficult to ascertain because no accurate

neurological examination is possible during the acute phase. Sudomotor and vasomotor disturbances are the rule. According to de Takáts,⁴³ there is invariably a vasodilatation, which he ascribes to the vasodilator action of the posterior root fibers (Bayliss²), and he goes so far as to state that this response is a point in the differential diagnosis between these painful states and hysterical paralysis in which the hand is generally cool. In Mayfield and Devine's³³ carefully observed series they found three patients with cold and nine with hot extremities, whereas in the author's eleven Naval and Marine Corps patients who were hospitalized at a somewhat later date after wounding the extremities were always considerably cooler than normal. It is important in this connection to remember that the sympathetic vasomotor nerves invariably serve as vasodilators to muscle and also carry a certain proportion of dilator fibers to the skin, in addition to supplying the entire innervation of the sweat glands.⁵³ For this reason excessive sympathetic activity in emotional states results in profuse sweating of the palms and soles, and at times warm but more often abnormally cool extremities. While de Takáts⁴³ has shown by oscillometric tracings that the vasodilator response is unilateral, the vasoconstriction and abnormal sweating usually involve the other extremities, although possibly to a lesser degree. It is quite possible that cutaneous vasodilatation is the characteristic condition in the early phase of causalgia, but after a time at least the opposite is frequently true. Everyone who has studied the condition has been impressed by the profuse sweating of the involved hand or foot, but nervous sweating of the hands and feet is a common phenomenon in wounded men, especially when pain is a prominent feature.

In the typical severe forms of causalgia the cutaneous hyperesthesia may become so intense that the patient cannot bear contact with clothing or even draughts of air. The extremity is kept constantly

* The term "hyperpathia" is used to connote widespread burning, throbbing, or tingling set up by mild cutaneous stimuli and spreading over a wide area. It is thus an exaggerated form of the hyperesthesia seen in the area of a regenerating nerve.

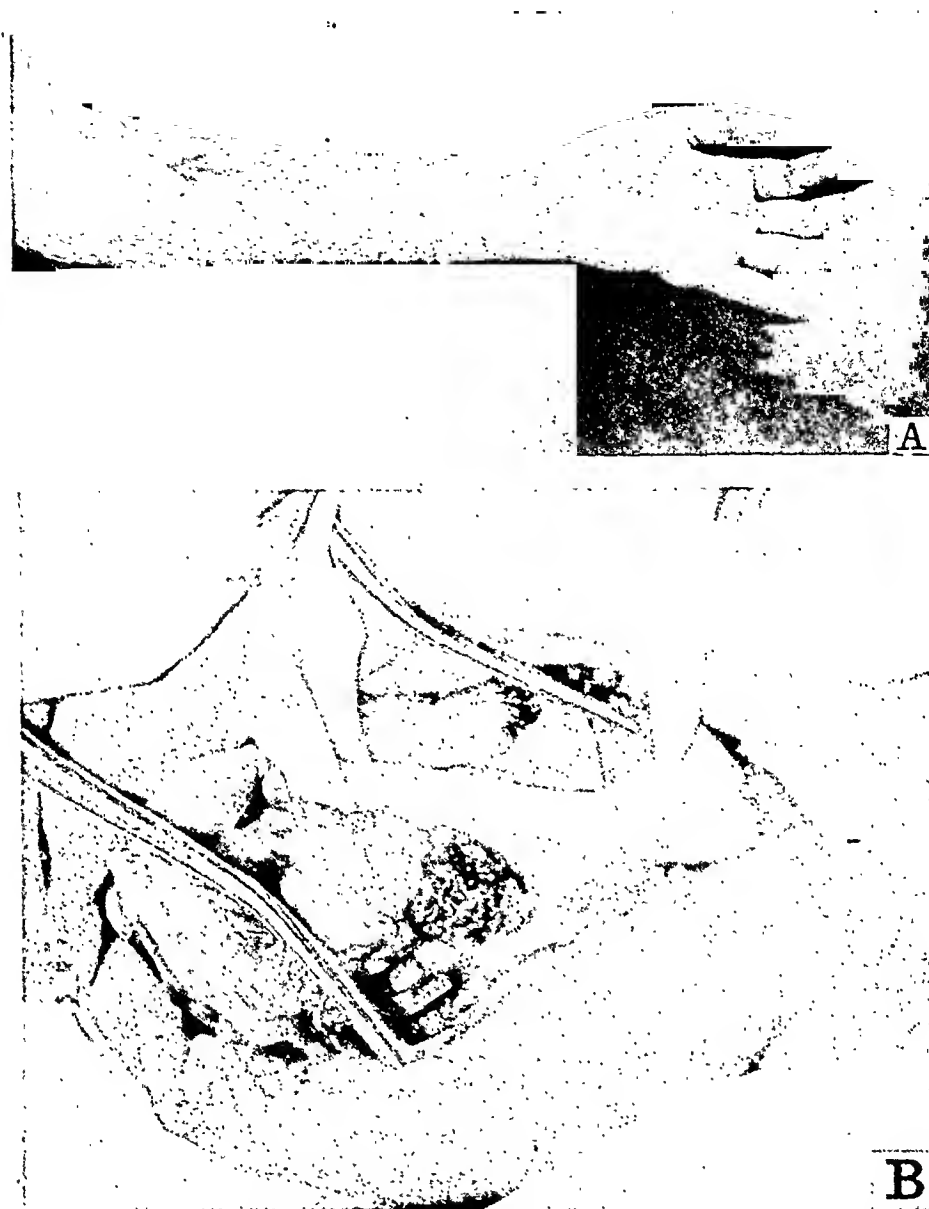


FIG. 1. Median nerve causalgia (Case 22). A, trophic changes in area of hand supplied by median nerve. The arrow marks the penetrating gunshot wound in the upper forearm. B, lateral scarring and adhesions of median are seen between points where nerve is elevated by rubber bands. The superficial head of the pronator radii teres muscle has been divided and spread by self-retaining retractor. Although neurolysis failed to benefit, all symptoms were relieved by subsequent sympathectomy.

protected and immobile, and must often be wrapped in a cloth or moistened with lukewarm or cold water. The patient becomes more and more a recluse and seeks to seclude himself from the noises and stimuli of an open ward. He cannot listen to tense or annoying radio programs or sit through an exciting movie. Any disagreeable stimulus, such as tickling or scratching the skin, or a hypodermic injection in any part of the body, produces unbearable pain in the affected extremity.

It has often been claimed that the condition is most likely to result after nerve wounds in which there is associated sepsis or arterial injury. The latter is certainly not an important feature, and most of the recently reported cases have not been preceded by major wound sepsis. Nevertheless, as healing following gunshot wounds has improved with better surgery since the time of the Civil War, the incidence of major causalgia appears to have steadily decreased. The outstanding reports in the

recent war have been presented by Doupe et al.,¹¹ seven cases from a large hospital for nerve injuries in England; Mayfield and Devine,³³ fifteen cases among 737 peripheral nerve injuries at the Percy Jones General Hospital; and Spiegel and Milowsky,⁴⁰ seven cases among 275 soldiers at another U. S. Army Hospital. The author's personal experience comprises eleven typical cases of classical causalgia in some 400 nerve injuries among the sailors and marines treated at the U. S. Naval Hospitals at Chelsea and St. Albans. The full-fledged condition is rarely seen in civilian practice, but an excellent account has been given by de Takáts.⁴³

Many aspects of the causalgic syndrome suggest that it is a form of psychoneurosis, and this diagnosis has often and most unfairly been applied to these victims. The fact that the whole pseudoneurotic picture so often clears immediately following suitable intervention, when the sufferer has lost his dread of pain, no longer requires sedatives, and can resume a normal life, indicates that the personality disturbance is a result rather than the cause of an unendurable condition. In the past, when no successful treatment was known, causalgia was a frequent cause of drug addiction and led either to deterioration into hopeless invalidism or to self-destruction. Psychological studies made on service personnel after successful treatment in the present war (Mayfield and Devine,³³ Spiegel and Milowsky,⁴⁰ de Takáts⁴³) have not brought to light any predisposing psychogenic factors.

Phantom Limb. The awareness of a phantom limb is a common phenomenon after amputation. Fortunately, this sensation is not generally associated with pain, and it usually fades away with the use of an artificial arm or leg. Occasionally, however, it fails to disappear, or may return months or years afterwards in an intensely painful form. The cause of this return is usually additional trauma, which may be either organic or psychic. Recurrence of pain years afterwards (eighteen years in

one of my cases) may be due to a fall with severe bruising of a leg stump and the resultant increase in scar tissue, or it may possibly be related to reduced circulation secondary to arteriosclerotic changes with advancing years. The etiological factors underlying the phantom phenomenon are still not definitely known. Unlike the causalgic states, the circulation and degree of sweating in the stump are rarely abnormal, and the phantom is not evoked by local stimulation or sudden psychic disturbances. Irritation within a neuroma of centrally conducting axones which supplied the missing part prior to its amputation was formerly believed to be the primary source of this peculiar sensation. A consideration of all the factors concerned, however, proves that this conclusion is not tenable. Evidence for this statement has been reviewed by K. E. Livingston²⁷ who cites the following points: (1) End bulb. neuromas do not develop quickly enough to account for the early phases of the phantom limb, which may be present immediately after amputation. (2) Stimulation of a stump neuroma never produces the phantom sensation, but rather the usual tingling over the autonomous area of the peripheral nerve. (3) The typical phantom never represents irritation in the distribution of any single peripheral nerve: viz., there is no such thing as an "ulnar" or "peroneal" phantom. (4) Re-amputation rarely alters the phantom pattern.

Another argument against the neuroma's being the focus of the phantom impulses, and one which Livingston fails to mention, is the fact that the uncomfortable position of the missing extremity so often duplicates the situation which existed prior to amputation.

All of these features point to the fact that the phantom sensation is integrated at higher levels in the central nervous system. At first this may be situated at the reflex spinal level, as suggested by W. K. Livingston.²⁸ The fact that phantom pain can at times be relieved by spinothalamic tractotomy proves that its origin,

in this stage at least, must be situated either within the territory of the peripheral or of the spinal sensory neurone. Its persistence after cordotomy, which is often the case, indicates that the phantom may become a projection of the sensory cortex.

At times the evolution of a painful phantom has all the appearance of being a purely psychic manifestation. This is illustrated by an unusual case report of Lt. Colonel Frank Mayfield.³² The patient, a tank soldier who had had his arm blown off above the elbow, had a perfectly comfortable upper arm stump until he applied for return to active duty. When this request was refused, he wanted to strike out with his amputated arm and clench his missing fist. He then became aware for the first time of his phantom hand, which remained clenched and painful. Although several neuromas were resected from the amputation stump, the phantom sensation was not relieved. However, as soon as he accepted the fact that he could not return to duty and asked for retirement, with the understanding that he could go overseas as a Red Cross Field Director, his phantom pain faded away. Evidence that this type of pain is often a central projection from the post-central cortex has been summarized by Riddoch³³ who points out that "the prevailing posture of the phantom is that of the part at the time of amputation. It is as if the postural model had become frozen when normal stimulation ceased." One thing is certain: Once this pattern has become fixed after prolonged physical and emotional disturbance, no interruption of the pain tracts can abolish it. The situation is similar to the tinnitus complained of by patients with Ménière's disease. This is usually cured by early section of the auditory nerve, but when it has been present for a long time it may persist, even though the attacks of explosive dizziness are successfully relieved.* Riddoch has given a most convincing

argument for believing that the phantom sensation is a projection arising from the post-central sensory association areas in the cerebral cortex. According to him:

"Stimulation by the processes of healing of the proximal ends of the divided nerves evokes sensations which are projected and interpreted as if the limb were still present. As has been said, they are never quite normal. These paraesthesiae, through simultaneous excitation of the schema underlying tactile localization and shape, are projected and animate the surface or outline model of the absent part. Similarly, irritation of fibres concerned with postural sensibility gives rise to impulses which help to keep alive the postural model, so that the phantom is correctly placed and moves with the stump. These sensations, in the absence of pain, are, however, weak, so that, as a rule, only the peripheral segments, the hand or foot, which are most richly endowed with sensory end-organs and fibres, are represented in the phantom. Retention of the phantom is in part due to the abnormal qualities of the tactile and other sensations, in spite of their relative weakness and the antagonistic evidence from visual and other senses. During the stabilizing process of healing of the divided nerves, sensory impulses diminish, and sensations become correspondingly fainter, with the dual result that the phantom is increasingly less obvious in outline and projection of it is defective. In consequence, it gradually approaches the stump, into which it finally disappears and fades away. A new shape of the body is now accepted. In other words, there is no longer a conflict in evidence from the patient's senses. If, however, the phantom is painful, which is usually the result of grossly abnormal conditions in the stump, the phantom may persist indefinitely and retain its original position. Further, the hand and fingers are not only much more obtrusive and clearly defined, but more of the amputated part is represented by it. Voluntary movement is restricted or impossible because of aggravation of pain."

* I am indebted to Brigadier D. Denny-Brown, RAMC, for this interesting analogy.

If this concept is correct, the development of a central projection would be expected to take time to become established in the sensory cortex, a point which has been mentioned by Riddoch and recently emphasized by Air Commodore C. P. Symonds.⁴²

A final point which requires consideration is the relationship between these three well known varieties of pain following injuries of peripheral nerves. Some writers believe that pain from a neuroma, causalgia, and the phantom limb phenomenon are merely different clinical manifestations of the same underlying disorder. Mayfield and Devine³⁵ believe that this similarity is remote and that causalgia is a clinical entity. Evidence now at hand also makes it possible to segregate the locally irritable end bulb neuroma and the phantom limb as separate and distinct entities. While resection of neuromas, when they are constantly subjected to muscle traction, lack of soft tissue protection, and pressure from a prosthesis, will usually eliminate local tenderness provided their reformation can be prevented, their removal in no way affects the pain of causalgia or a phantom limb. These last conditions are dissimilar, at least in the way they respond to emotional stimuli and react to the abolition of the peripheral hypothalamic discharge following sympathectomy. The response of causalgia is nearly always favorable, while a painful phantom cannot often be influenced by this procedure. Lt. Colonel Woodhall³⁴ has been fortunate enough to observe the response in two patients who suffered from both conditions simultaneously. After preganglionic sympathetic denervation of the upper extremity, the burning hyperpathia which had been so distressing after any exposure to cold or emotional stimuli disappeared, but the disagreeable cramp-like positions of the phantom hand remained.

While this discussion has been concerned with only three separate and distinct types of pain secondary to nerve injury, this does not imply that other varieties do not

exist. Indeed many atypical varieties are seen. Sudeck's atrophy, painful osteoporosis, and the "minor causalgia" described by Homans²³ fall into this group, but only certain cases of the latter have followed direct injuries to the nerves. In these the pain has been less intense and less widespread than in the major causalgic syndrome, but many have responded equally well to chemical blocking and sympathectomy. Other less common conditions are seen so seldom and have so few points in common that it is impossible to give any general description of their symptomatology and treatment. Every neurosurgeon, however, is acquainted with old amputees who have crises of spasmodic severe pain in their stumps or other unusual manifestations which do not fall into any of the categories described above. Similar problems are occasionally encountered following severe fractures of the pelvis and hip. These are most difficult and yet stimulating cases to treat, as each constitutes a new and individual problem.

TREATMENT

Despite our lack of a fundamental understanding of post-amputation neuralgia, causalgia, and the painful phantom disturbances, several facts stand out clearly and require emphasis. Pain, considered by Hilton²² and by Mackenzie³⁰ as a protective mechanism, may become a destructive force, dangerous to the victim's morale. As pointed out above, when pain of this type is allowed to become chronic, the cerebral cortex may become involved in its projection, so that no peripheral operation can relieve it; in addition, the patient usually develops an addiction to morphine and his personality deteriorates. Even in the less severe cases, painful hyperesthesia prevents active and passive movement of associated joint and soft tissue injuries, and thereby leads to contractures, osteoporosis, and a great variety of trophic disturbances. Watchful waiting, in the hope that the pain will disappear spontaneously, is therefore not advisable for

more than a very limited period. For these reasons we are forced to formulate a program to be undertaken when all conservative orthopedic, physiotherapeutic and neuropsychiatric measures have been tried and have failed.

Before recourse to surgery, it is always essential to bear in mind that any ill advised operation is likely to make the patient worse. The following pitiful case illustrates many of the difficulties in the treatment of post-traumatic pain. A French soldier of World War I received a penetrating wound of the hand, which led to chronic suppuration, fibrosis and pain. In the following ten years he had undergone a long series of operations including amputation above the wrist, resection of painful neuromas and subsequently progressive amputations up the arm which ended with a painful shoulder stump and an intensely disagreeable phantom of the original wounded hand. Periarterial sympathectomy of the subclavian artery and section of the posterior roots of the brachial plexus failed to put an end to his suffering, which was finally terminated in 1927 through suicide by hanging. At that time little was known about what to do and, equally important, what not to do about a case of this sort. We are learning slowly, and many points are illustrated by this tragic story. In the first place, it is vitally important not to undertake any ineffective procedures. Colonel F. M. McKeever³¹ has observed that the pain in an amputation stump is usually increased by any operative procedure such as simple revision of flaps in which the nerve stumps are not even exposed. Progress has been made since World War I through the realization that certain procedures are useless and should no longer be considered. These include:

1. *Repeated Resections of Neuromas.*

2. *Neurectomies or Interruption of Nerve Trunks at Higher Levels.* Livingston²⁸ has recorded a resection of the brachial plexus in a painful upper arm stump without benefit, and the writer has had a similar experience; numerous other case reports

since the time of Mitchell, Morehouse and Keen³⁵ are on record which attest its futility. Another variation of this procedure is the transection of a painful nerve trunk with immediate suture to prevent neuroma formation. Leriche²⁵ described its use but without striking results.

3. *Reamputation for the Relief of Pain.* Reamputation, as emphasized by Leriche²⁵ and Riddoch,³⁸ must never be considered, as the pain nearly always recurs in the new stump and usually is made a great deal worse. There is only one exception to this rule: When the stump is badly constructed and a liability on mechanical grounds, a reconstruction may be in order. Such a revision must be done at an early date, however, if it is to have any chance of relieving pain.

4. *Periarterial Sympathectomy.* Successful results in minor forms of causalgia and amputation stump pain after this operation have been recorded by Leriche²⁵ and Homans.²³ Leriche,²⁵ however, states that it should not be considered when the neuralgia is severe. Yet this unphysiological procedure is constantly mentioned in treatises on pain after nerve injury, such as Groff and Houtz's¹⁷ recent book, but without the statistical backing of successful case reports. It is the author's personal feeling that the operation is non-specific and that its effects are due to the transitory rise in peripheral circulation (or reduction of vasomotor tone) that accompanies the increased elimination of heat following any injury to the tissues. Similar effects can be produced more simply by procaine block of the vasoconstrictor nerves or by fever therapy. In this connection, it is of interest to record the observation made by Mayfield and Devine³³ at the Percy Jones General Hospital that soldiers with malaria are often relieved of pain from nerve injuries during bouts of fever.

5. *Intrathecal Injection of Alcohol.* This procedure, proposed by Dogliotti,⁹ has been advocated for the relief of painful amputation stumps in the lower extremity. On the Neurosurgical Service at the Massa-

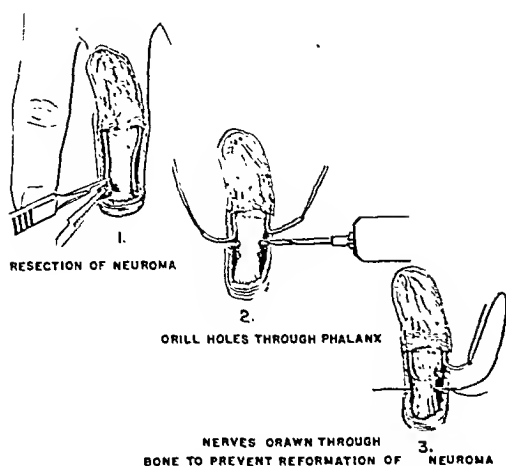


FIG. 2. Prevention of neuroma formation by drawing cut end of nerve through drill hole in neighboring bone, as suggested by Boldrey.⁴ (Reproduced from article by White⁵⁰ with the kind permission of the U. S. Naval Medical Bulletin.)

achusetts General Hospital it has been successful only once out of seven trials. Furthermore, it carries a greater risk of paralyzing the bladder than section of the spinothalamic tract. For any patient who has chronic pain and is even a fair surgical risk, it is preferable to cut the pain tracts in the spinal cord.

6. Posterior Rhizotomy. Extensive sectioning of the posterior roots of the brachial plexus is a dangerous and mutilating procedure. The widespread and complete loss of sensation which follows is both annoying and incapacitating to the patient, if he has a useful stump. For this reason, and even more because the anesthetic stump usually continues to be painful, this procedure should never be undertaken. One of our patients with a painful amputation stump at the shoulder continued to suffer after division of all the posterior spinal roots from the third cervical down through the third thoracic. Riddoch²⁸ also emphasizes the futility of posterior rhizotomy in these cases, and states that he has seen the pain continue after the anterior as well as the posterior roots of the brachial plexus had been cut.

With the realization that the procedures mentioned above are ineffective and often dangerous, what is left for the surgeon to

do when he is confronted with these serious problems? There are two simple operations that are often helpful and involve little chance of making matters worse:

1. Single Resection of a Painful Neuroma.

A single resection of a sensitive neuroma is distinctly worth trying, particularly if the hyperesthesia is localized and can be relieved by local infiltration of procaine. (Table 1.) Formerly these neuromas reformed and pain recurred within a few weeks (Leriche,²⁵ Bailey and Moersch¹). Injection of the fresh nerve stump with alcohol does little to delay the reappearance of the neuroma, but injection of 20 per cent formalin or a 1 per cent aqueous solution of gentian violet is more effective (Guttmann and Medawar²⁰). This has proven fairly effective in five service patients, although follow-up observations do not extend beyond a few months. (Table 1.) Boldrey's⁴ suggestion of drawing the nerve end through a drill hole in a neighboring bone (Fig. 2) is proving an effective method of preventing the reformation of a neuroma. At the U. S. Naval Hospitals in Chelsea and St. Albans, we have treated intercostal and digital nerves in this fashion in five patients with satisfactory relief of the local symptoms in four (Table 1.) Another technic, which was developed by Colonel R. G. Spurling and has continued to give satisfactory results in the hands of Lt. Colonel Barnes Woodhall at the Walter Reed General Hospital and of Captain White and Lt. Commander Hamlin at the U. S. Naval Hospital in Chelsea, is to cover the end of a nerve from which a neuroma has been removed with a snugly fitting cap of thin sheet tantalum. A description of this method has also recently been given by Coburn.⁸ The procedure is illustrated in Figures 3A and B. This gave fairly satisfactory relief of the local symptoms in Case 5, but only temporary benefit in Case 7. Both Woodhall and White have had occasion subsequently to remove a few of these metallic caps, and have been impressed by the absence of neuroma formation. More recently Edds¹² has sug-

TABLE I

RELIEF OF LOCAL HYPERESTHESIA BY EXCISION OF NEUROMA MODIFIED BY PROCEDURES TO PREVENT REFORMATION

Case	Condition	Surgical Procedure	Result
1. Henry T. Pvt. USMC	Intercostal nerve caught in scar following gunshot wound. Neuralgic pain.	1) Diagnostic procaine intercostal block. 2) Intercostal nerve severed on entering scar and drawn through drill hole in rib.	Temporary relief. Nearly complete freedom from former pain at 1 mo.
2. Henry J. CM 3/c USN	Traumatic amputation of distal phalanges 4th and 5th fingers. Local tenderness and deep ascending neuralgia.	1) Plastic revision of poorly constructed 5th finger stump, excision of neuromata, and drawing of digital nerves through drill hole in middle phalanx. 2) See Table II.	Relief of local hyperesthesia only, but persistent ascending neuralgia and continued hyperesthesia in stump of 4th finger.
3. John G. S 3/c USN	Traumatic amputation 2nd and 3rd fingers. Exquisite pain in stumps and deep aching through hand and forearm. Cold, cyanotic, sweaty hand.	1) Digital nerves of 3rd finger freed from terminal neuromata and drawn through drill holes in proximal phalanx. 2) See Table II.	Relief of local hyperesthesia of middle finger, but no effect on deep ascending pain, index finger still hypersensitive at 2 mos.
4. Roy B. S 1/c USN	Severe scarring of sides of index finger by crushing accident. Local hyperesthesia of both sides of finger.	1) Paravertebral sympathetic ganglion block. 2) Amputation of finger tip. Lateral digital nerve drawn through drill hole in proximal phalanx.	No effect on pain. Loss of hyperesthesia over lateral side of finger at 7½ mos., with persistence of pain on medial side.
5. Philip C. Sgt. USMC	Traumatic amputation of tip of 5th finger, with repeated amputations to metacarpal level for local tenderness of stump and deep aching pain.	1) Resection of neuroma from medial digital nerve, and enclosure of stump in tantalum cap. 2) and 3) See Table II.	Relief of hyperesthesia only, with no effect on underlying neuralgia at 4 mos.
6. Cleveland J. SC 2/c USN	Traumatic amputation tip of middle finger with severe hyperesthesia.	1) Resection of neuromata and burial of digital nerve ends in drill hole through bone of 2nd phalanx. 2) Revision and shortening of painful stump. Digital nerves injected with 20% formalin.	Little improvement. A month later patient stated that all severe pain had gone. Slight tenderness persisted.
7. Francis O'C. V.A.P.	Traumatic amputation below knee with excruciating tenderness over end of peroneal nerve. Also, occasional shooting pain into missing lower leg.	Excision of neuromata of superficial and deep branches of common peroneal nerve. Two ends of nerve covered with tantalum cap (Fig. 3b).	Relief of local tenderness lasted 3 mos., then patient noted partial recurrence with superimposed diffuse neuralgia of stump.
8. Ingrid K. Y 2/c	Neuroma of thenar branch of superficial radial nerve following removal of ganglion.	Neuroma excised and end of nerve injected with formalin.	Returned to duty. At 3 mos. had mild discomfort on cold days.
9. Otis W. MM 3/c USN	Traumatic amputation through 2nd and 3rd metacarpal heads with local pain and hyperesthesia in scar.	Resection of 3 large neuromata and injection of nerve ends with 20% formalin.	Pain free at 2 mos.
10. Earl F. S 1/c USN	Traumatic amputation of ring finger through proximal phalanx. This stump so tender patient was unable to grip anything in the hand.	Excision of digital neuromata and injection of nerve ends with 20% formalin.	Pain free at 2 mos. and able to use hand freely.
11. Theodore Y. Sgt. USMC	Painful neuroma in cicatrix over radial side of ring finger.	Excision of neuroma of digital nerve and injection with 20% formalin.	Pain free at 1 mo.

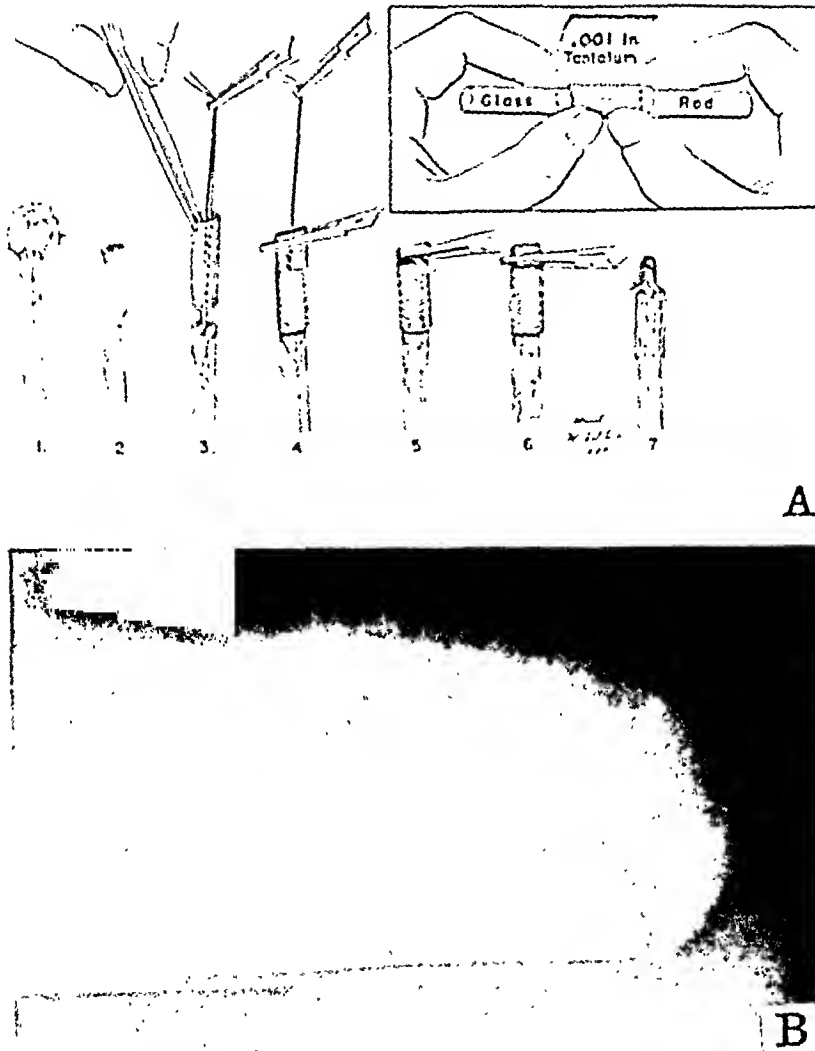


FIG. 3. Application of tantalum cap to stump of nerve for prevention of neuroma formation. A, (1) and (2), resection of painful end-bulb neuroma; (3), the amputated end of the nerve is transfixed by a fine silk stitch and covered by a sleeve of tantalum; (4), the open end of the sleeve is crushed in a hemostat; (5) and (6), the flattened end is turned back on itself and crushed again, thereby fixing it firmly to the end of the nerve. (Reproduced from article by White and Hamlin⁴² with the kind permission of the J. of Neurosurgery.) B, x-ray showing cap of .001 inch tantalum placed over ends of superficial and deep peroneal nerves (Case 7).

gested painting the nerve end with 10 per cent solution of methyl methacrylate in acetone. In animal experiments it was found that the acetone causes complete chemical fixation of the nerve end, which is also imprisoned in an impervious plastic cap. Neuroma formation was never observed and the nerves tapered gradually to their blind ends. Theoretically, this method of encasing the end of the nerve in a non-irritant Lucite cap should be a

simple and most practical solution of the neuroma problem, but we have been unable to obtain any human statistical results to date.

The methods reported above are all simple and theoretically sound procedures. They deserve careful clinical trial, but nevertheless it must be borne clearly in mind that the period of follow-up is still too short to permit any accurate assessment of their value.

2. *Sympathectomy*. In patients with vasomotor and emotional disturbances, which are so commonly found in these painful states, much can be done by the elimination of the regional sympathetic outflow to the painful extremity. This can be accomplished either by repeated chemical blocking with procaine or by sympathectomy. The technic of these procedures has been described by White and Smithwick¹¹ and by White¹¹ in Bancroft and Pilcher's "Surgical Treatment of the Nervous System." The relief of pain, as stated above, is not brought about by any interruption of afferent impulses, as these do not run in the peripheral sympathetic system, but by correction of abnormal circulation and interruption of sympathetic influences on the irritated sensory nerve fibers. Evidence for this is that these patients are more comfortable when protected from psychic stimulation (Doupe et al.¹¹) and during the reduction of sympathetic vasoconstriction which occurs in warm weather, in sleep, or when circulation is improved after artificial fever induced in a hypertherm, by injection of foreign protein, or by a malarial chill (Mayfield and Devine³³). By far the most practical test is the paravertebral infiltration of procaine around the upper thoracic or lumbar sympathetic ganglia. Many favorable results have been reported by Leriche,²⁵ White and Smithwick,³³ Homans,²⁵ de Takáts and Miller,⁴⁴ Livingston,²⁵ and by Doupe and his collaborators.¹¹ Sometimes long-lasting relief has followed a single or several repeated injections.

When pain is relieved during the period of sympathetic block, but reappears as the drug is absorbed, there is a very good chance that surgical interruption of the regional sympathetic ganglia will bring about lasting relief. In cases of burning pain and hyperesthesia, this is almost a certainty. Experience with nineteen such cases is summarized in Tables II and III. This method is most effective when the pain results from a nerve lesion in the lower arm or leg with associated vaso-

spasm, and particularly when the pain is increased by emotional stimuli. The improvement in Case 14, in which pain developed in a mid-thigh stump with arteriosclerotic changes thirty years after amputation, was a distinct surprise, as there were no associated vasomotor or psychic correlations. Here the immediate result was excellent, but after eight months was no longer satisfactory, due presumably to some further reduction in the circulation of the scar. In Case 5, a Marine sergeant with a painful fifth finger stump of ten years' duration, sympathectomy has failed to relieve deep aching pain in the hand completely, but the patient is nevertheless distinctly grateful for the partial relief and the greatly improved circulation in his hand. In all eleven of the patients with typical Weir Mitchell causalgia, sympathectomy has been a striking success. (Table III.) In these cases, local neurolysis and freeing of the nerve from a surrounding cicatrix or resection of a lateral neuroma are seldom successful (Mayfield and Devine,³³ Spiegel and Milowsky⁴⁰). Neurolysis or suture of the injured nerve to relieve pain is justifiable only when there is definite paralysis and when the causalgia is so mild that the surgeon can afford to wait for a period of months while the irritated nerve fibers regenerate. If the pain is really severe, it is far better judgment to perform the sympathectomy first (provided there has been a promising response to paravertebral procaine block) and to postpone any necessary local repair of the nerve trunk until afterwards. Patient 22 in Table III serves to illustrate this point. Here a bullet had passed close to the median nerve, which was bound down by a band of scar tissue to the deep head of pronator radii teres. (Fig. 1B.) Freeing the nerve and transplanting it into a bed of healthy muscle had no effect on the burning pain in the hand, but this was later relieved by sympathectomy.

Preganglionic denervation of the upper extremity and resection of the second and third lumbar sympathetic ganglia are both

TABLE II
RELIEF OF LOCAL PAIN AFTER AMPUTATION BY INTERRUPTION OF SYMPATHETIC FIBERS

Case	Condition	Surgical Procedures	Relief
2. Henry J. CM 3 c USN	Traumatic amputation of distal phalanges of 4th and 5th fingers. Very cold, cyanotic, sweaty hands.	1) See Table I. 2) Paravertebral procaine block, T1-T2. 3) Upper thoracic preganglionic sympathectomy.	Temporary relief. Warm hand and arm free of former deep pain at discharge (3 weeks).
3. John G. S 3 c USN	Traumatic amputation 2nd and 3rd fingers. Local hyperesthesia in 3rd finger had been relieved by excision of neuroma, but without effect on neuralgia of hand and forearm.	1) See Table I. 2) Paravertebral procaine block T1-T2. 3) Upper thoracic preganglionic sympathectomy.	Temporary relief. Complete relief of ascending neuralgic pain. Patient still complained of hypersensitive index finger, but was able to return to limited duty.
5. Philip C. Sgt. USMC	Traumatic amputation tip of 5th finger with repeated amputations to metacarpal level for local hyperesthesia and deep ache in hand and arm. Cold, cyanotic hands.	1) See Table I. 2) Procaine block of upper thoracic ganglia. 3) Upper thoracic preganglionic sympathectomy.	Relief for 2 hours. Nearly complete relief of deep aching pain in hand and arm at 3 months.
12. Roger P.*	Crush of index finger and amputation associated with cold, clammy hand; pain in hand radiating up inner arm to pectoral region.	1) Reamputation of finger. 2) Paravertebral procaine block T1-T2. 3) Cervicothoracic ganglionectomy.	None. Relief for 2 hours. Slight recurrence of pain 1 yr. after operation, on partial recovery of vasoconstriction and sweating.
13. Roland L.*	Traumatic amputation of index finger associated with cold, sweaty hand.	1) Reamputation of finger. 2) Paravertebral procaine block T1-T2. 3) Cervicothoracic ganglionectomy.	None. Transitory relief. Permanent relief.
14. James B.*	Burning pain developing in stump 30 years after thigh amputation; pain present for 3½ years.	1) Section spinothalamic tract with sensory level at T12. 2) Paravertebral lumbar procaine block. 3) Paravertebral lumbar procaine block. 4) Paravertebral lumbar procaine block. 5) Lumbar sympathectomy L1-L3.	Relief for 4½ mos. with recurrence following transurethral prostatectomy. Relief for 2 days. Relief for 4 weeks. Relief at discharge. Relief for 7 months, then partial recurrence.
15. Henry C. S 2 c USN	Traumatic amputation of 3rd toe, with severe pain in stump and bottom of foot. Aggravated by cold, not by psychic stimuli.	1) Paravertebral procaine block. 2) Lumbar sympathectomy L2-L3.	Temporary relief. Complete relief at 2 mos.
16. James L. AB R.N.	Traumatic metatarsal amputation with painful vasospasm. Deep ache in end of foot, which became much worse in cold weather and ascended to knee.	1) Paravertebral procaine block. 2) Lumbar sympathectomy L2-L3.	Temporary relief. Excellent result.

* Civilian cases, treated at Massachusetts General Hospital, Boston.

TABLE III
RELIEF OF CAUSALGIA BY PREGANGLIONIC SYMPATHECTOMY

Case	Wound	Paralysis	Distribution of Pain	Time of Onset after Wounding	Hyperpathia	Trophic Changes	Temperature of Extremity	Sweating	Relation to:		Operations in Addition to Sympathectomy	Result of Sympathectomy
									Cold	Emotion		
17. Chas. R. Pfc. USMC	Small shell fragments L. upper arm.	Median nerve (partial)	Entire hand.	Few hours.	+++	+++	Cool.	+++	+++	+++	None.	Complete relief, now plays strenuous games.
18. Fred. S. Pvt. USMC	Shell fragments upper arm and forearm.	Median nerve (partial), ulnar nerve (complete).	Entire hand.	5 hours.	+++	++	Cool.	+++	+++	+++	Subsequent median neurolysis and ulnar nerve suture.	All hyperesthesia cleared. Slight residual ache in finger tips.
19. John H. Maj. USMC	Upper humerus fractured by shell fragment. Aneurysm.	Median nerve (complete), ulnar nerve (partial).	Entire hand.	Immediate.	++	+	Cold.	++	++	+++	Aneurysmorrhaphy. Median nerve will require suture later.	Complete relief.
20. Norman C. Pfc. USMC	Machine gun bullet passed between two upper forearm bones.	Median nerve (partial).	Entire hand.	Few hours.	++	+++	Cool.	++	++	o	Previous neurolysis & partial suture of median nerve with partial relief.	Complete relief.
21. Chas. M. Pfc. USMC	Rifle bullet through upper arm. Artery severed.	Median & ulnar nerves (complete).	Entire hand.	2 weeks after operation for aneurysm.	++	+	Cold.	++	++	++	None.	Complete relief.
22. Nathan V. Pvt. USMC	Rifle bullet through upper forearm, fractured ulna.	Median nerve (partial).	Median distribution.	.....	++	+++ (median area).	Cold.	++	+	++	Neurolysis median nerve without relief. (Fig. 1.)	Complete relief.
23. Robt. B. Cpl. USMC	Bullet wound brachial plexus, fractured clavicle, severed artery.	Median and ulnar nerves (partial), medial ante-brachial cutaneous nerve (complete).	Entire hand.	1 week.	+++	++	Cool.	o	++	+++	None.	Hyperpathia of hand gone, but at times slight residual pain elbow and wrist.
24. Alfred D. Pfc. USMC	Mortar wound median side of arm, axilla to mid forearm.	Median nerve (partial).	Median area of hand.	Day after wound.	+++	+	Cool.	+	++	++	None.	Complete relief.
25. Howard W. Pfc. USMC	Bullet wound below elbow.	Median nerve (partial).	Median area of hand.	Immediate.	++	+	Cold.	+++	++	++	Previous median neurolysis, without improvement.	Complete relief.
26. Harold O. Pfc. USMC	Shell fragment wound of internal condyle of elbow.	Ulnar nerve (partial).	Ulnar area of hand.	.....	++	+	Cold.	+++	++	++	None.	Complete relief.
27. Wm. M. Cpl. USMC	Phosphorus grenade fragments in lower leg.	Common peroneal (partial), sural nerve (complete).	Entire foot and toes.	Immediate.	+++	++	Cold.	++	++	++	None.	Nearly complete relief.

safe and non-mutilating procedures. They therefore deserve serious consideration and early testing by procaine block when incapacitating pain persists in a peripheral nerve wound or amputation stump, especially when this is accompanied by abnormal vasomotor, sudomotor or psychic manifestations. When pain disappears for the duration of the chemical sympathectomy, the patient with stump neuralgia should be told frankly that, while complete relief cannot be guaranteed, there is distinctly better than an even chance for a satisfactory outcome, and a certainty that the abnormal peripheral circulation and sweating will be rectified. In the case of the worst causalgias, the outlook is even more promising. The results in the eleven cases summarized in Table III are almost completely satisfactory, and a similar outcome has been recorded in twenty-nine other cases reported by Doupe and his co-workers,¹¹ Mayfield and Devine,³³ and by Spiegel and Milowsky.⁴⁰

Examination of Table I shows that the local tenderness over a neuroma can often be relieved by removing it, provided regrowth of axones into the scar can be prevented. On the other hand, widespread, deep, aching pain or hyperesthesia are not influenced by this procedure, but often respond well to sympathectomy. (Table II.)

How often the painful phantom phenomenon can be relieved by sympathectomy is still uncertain. De Takáts⁴³ has recommended its trial and Livingston²⁸ has reported some favorable results, but in the author's limited experience this procedure has not proven successful. Woodhall⁵⁴ has reported a most instructive case in which a young Army lieutenant suffered simultaneously from burning causalgic pain in his lower amputation stump and from a disagreeable phantom of the missing hand contracted in the position in which he last saw it prior to its amputation. A month after an upper thoracic preganglionic sympathectomy the patient stated that he was relieved of his causalgic pain but that the phantom of his hand still persisted.

When these relatively simple and innocuous operations cannot be used the surgical attack must be shifted to the central nervous system. Before recourse to more radical intervention on the spinal cord or brain can be considered, all aspects of the problem should be reviewed with a competent neuropsychiatrist. Lidz and Payne²⁶ have cited the case of a young soldier who shot off the middle finger of his right hand while cleaning his rifle. Typical severe causalgia developed seven weeks later when he heard that his unit believed that the wound was self-inflicted to avoid service at the front. The pain persisted until the situation was explained to him and he was given encouragement under the influence of sodium pentothal. When he decided to prove himself in combat and regain the respect of his friends, the entire condition cleared up.* Successful results of this sort are, unfortunately, extremely rare.

The available surgical procedures on the spinal cord and brain are mutilating operations. They may involve serious complications and, if they fail, will add another psychic trauma with further reduction of the patient's morale. Recourse to such radical surgery can, therefore, be undertaken only in desperate cases in which pain is so severe that the patient threatens to become an addict to morphine, a psychopathic problem or a suicide.

3. *Section of Spinothalamic Tract.* Interrupting the anterolateral spinal (spinothalamic) tract by which painful impulses reach the brain is in general far more effective than cutting the posterior roots over which they enter the spinal cord. From personal experience to date, there is good reason to believe that pain and tenderness which are located within the stump itself can usually be relieved by

* It would be of great theoretical interest to know whether this dramatic result was brought about by lessening the tonic sympathetic impulses to the extremities which are so greatly increased at times of emotional disturbance. Cobb⁷ has recorded instances of the development of Raynaud's phenomenon during periods of intense psychic strain, so this possibility would fit in well with Doupe's¹¹ theory of production of causalgic pain.

TABLE IV
RELIEF OF LOCAL PAIN AFTER AMPUTATION BY SECTION OF SPINOTHALAMIC TRACT*

Case	Condition	Level of Analgesia	Relief
14. James B.	See Table II.	12th thoracic segment.	Relief for 4½ months, with recurrence following transurethral prostatectomy. This patient's problem complicated by a senile psychosis. (See Table II.)
28. William D.	Gritti-Stokes amputation for thromboangiitis obliterans, then complained of deep aching pain in stump, 3½ years' duration.	9th thoracic segment.	To death, 3½ years later; this patient subsequently developed pain in stump of other leg after a second Gritti-Stokes amputation, and painful gangrene of fingers; died after cervical cordotomy on opposite side.
29. Nellic T.	Burning pain in stump since thigh amputation for osteomyelitis 8 years before; at other hospitals had had unsuccessful sciatic neurectomy, multiple excisions of neuromas and intrathecal alcohol injection; latter caused bladder disturbances for 1 year.	8th thoracic segment.	Complete relief at 3 mos.
30. Emma H.	Mid-thigh amputation following septic abortion; local pain in stump of 2 years' duration; previous intrathecal alcohol injections had paralyzed bladder without mitigating the pain.	10th thoracic segment.	Complete relief for over 7 years, but has complained of radicular pain at level of laminectomy. This has disappeared in last 4 years.
31. Ralph T.	Traumatic thigh amputation above knee in World War I; for past 7 years crises of bursting pain in stump of great intensity, especially at night. Pt. had well-formed, non-tender stump, and walked freely with artificial leg. Temporary relief following spinal anesthesia to T6.	9th thoracic segment.	Complete relief to date, 2½ months.
32. Daniel M.	Traumatic low thigh amputation 3 years previously. Tenderness and burning pain in stump, driving pt. to drink, unable to use artificial leg. Previous excision of sciatic neuroma with recurrence and local tenderness. Temporary relief following full spinal anesthesia.	9th thoracic segment.	Complete relief at 6 weeks. Pt. walked out of hospital on his artificial leg.
33. John D.	Low thigh amputation 14 years previously for malignant tumor of tibia, followed in last 4 years by deep aching, burning pain. Pt. becoming an alcoholic on this account. No local areas of tenderness.	11th thoracic segment.	Complete relief at 3 weeks.

* All of these were civilian patients, operated upon at Massachusetts General Hospital, Boston, by Drs. W. J. Mixer, J. S. Hodgson, and J. C. White.

cordotomy. Seven cases are summarized in Table IV, six of which obtained satisfactory relief. The situation in the other, Case 14, was complicated by his senile psychosis and mental attitude toward his complaint.

In the case of severe phantom manifestations the decision as to whether relief can be obtained by spinothalamic tractotomy becomes most difficult. In the

extensive experience of Bailey and Moersch¹ at the Mayo Clinic, this operation has failed consistently. Riddoch,³⁸ however, is not so pessimistic and has stated that "when pain in the phantom is successfully abolished by lateral chordotomy or early removal of abnormalities in the stump, the phantom may behave as if it had been painless from the first." These points are

TABLE V

RELIEF OF PHANTOM LIMB PAIN AFTER AMPUTATION BY SECTION OF SPINOTHALAMIC TRACT*

Case	Condition	Level	Relief
34. Charles W.	Pain in phantom foot for 18 years following thigh amputation; 2 previous unsuccessful resections of neuromas.	Not recorded.	At $2\frac{1}{4}$ years patient remains comfortable, although at times there is slight throbbing sensation in phantom little toe; spasmodic jumping of stump has ceased.
35. Arthur N.	Crushing pain in phantom ankle following hip disarticulation for sarcoma 2 months previously.	7th thoracic segment.	In good condition and free from pain at 27 months, but has had awareness of phantom with some sense of stiffness in foot and big toe.
36. Homer A.	Pinching, burning pain in phantom foot 7 months after hip disarticulation.	9th thoracic segment.	Complete loss of phantom sensations at 8 months; still complains of spasmodic jerking of stump with sense of muscle cramp and of mild radiculitis at level of laminectomy incision.

* All of these were civilian patients, operated upon at Massachusetts General Hospital, Boston.

borne out by Case 33 below. Nevertheless, Riddoch agrees that no relief can be expected when the pain has been stamped indelibly on the cerebral cortex. This means that a cordotomy performed without too long delay, and particularly before the patient becomes addicted to morphine, stands the best chance of success. Although it has not yet been proved. I believe that spinal anesthesia should offer the best chance of weeding out the patient with pain of central origin following an injury to the lower extremity.* In cases of arm pain, procaine block of the brachial plexus can accomplish the same purpose, and it has been demonstrated that it does not relieve pain which originates in the cerebral cortex (Michelsen³⁴).

On the Neurosurgical Service at the Massachusetts General Hospital we have cut the spinothalamic tract in three patients complaining of painful leg phantoms. (Table v.) It will be seen that the severe

crushing or pinching pains in the phantom foot have been relieved in each instance. In the first patient (Case 34), whose phantom sensations had been present for eighteen years, it is remarkable that relief from pain should have been so complete. He writes: "No sensation to speak of in the missing leg, but some throbbing at times in the little toe and ankle bone. No movement of the foot or toes. The operation has also eliminated the spasmodic jumping of the stump to almost 100 per cent." The second patient (Case 35) has had a sense of stiffness in his phantom ankle and big toe but no pain. The third (Case 36) states that he has lost all sense of his phantom, but that when the muscles of his stump contract he is still aware of the cramp-like sensations. This is not a sufficiently large series from which to draw definite conclusions, but it does prove that cordotomy can help in certain cases. So far there have been no published successful reports of cordotomy performed for phantom pain in the upper extremity, although the operation has been attempted three times by Grant¹⁶ without success. For a high spinothalamic tractotomy the incision in the anterolateral column is made at the second or third cervical segments, but it is not easy to raise the level of analgesia to the uppermost outflow of the brachial plexus.

* A recent experience of Dr. W. J. Mixer's³⁵ at the Massachusetts General Hospital proves that this is not invariably true. The patient, who had local pain in his thigh amputation stump which radiated toward his missing knee, continued to experience his pain after an apparently complete spinal procaine block. Cordotomy, however, has resulted in complete relief over a period of nine months. Dr. Stanley Sarnoff is now making a careful study of the diagnostic value of spinal anesthesia in this field at the Massachusetts General Hospital, and his results will soon be reported.

It is more logical to cut the spinothalamic tract at the medullary level (Schwartz and O'Leary;³⁹ White⁴⁸). In the case reported by White neuralgic pain, which involved both the upper thoracic and upper cervical roots, was successfully relieved, although at the expense of some residual ataxia. This complication occurred because in these earlier attempts the spinothalamic tract in the medulla was sectioned just below the level of outflow of the most caudal vagal rootlets, too close to the vestibular nuclei at the base of the restiform body. Sweet,⁴¹ in four operations performed during the recent war for intractable pain entering the cord over cervical roots, has avoided this risk of injury to the inferior cerebellar peduncle by making the incision into the side of the medulla at a slightly lower level. He has obtained effective analgesia over the entire arm area in each case without any persistent complicating disturbance of postural control, and in two patients with an adequate period of postoperative observation the relief appears to be permanent. One of these patients had the phantom of a painful hand protruding from his shoulder amputation stump. Much further surgical experience is required to establish the chances of successful relief of phantom pain. At present cordotomy appears to give this in about half of the reported cases, but when its use is strictly limited to those subjects in whom the pain can be relieved by complete spinal anesthesia, the percentage of effective results should rise to a more satisfactory level.

In cases in which pain is definitely of central origin two methods have recently been proposed for its surgical elimination at the highest levels in the brain itself:

4. *Resection of Sensory Cortex.* In certain sufferers from major amputation stump neuralgia we shall be forced to decide whether, in the presence of phantom sensations with evidence of psychic projection of the painful manifestations, we are justified in taking Riddoch's³⁸ and Leriche's²⁵ still earlier suggestion and extirpating the postcentral convolution of

the cerebral cortex. Riddoch believes that the phenomena of the phantom limb, such as the persistence in the phantom of pain and postural sensations which antedate the amputation, can be explained only on the basis of cortical representation. He has stated that "destruction of the cortical sensory receptive mechanism in the parietal lobe, which is concerned with the development of postural and surface models and with recognition of change, causes immediate abolition of the phantom limb." This theory is corroborated by the case reported by Head and Holmes²¹ in which disappearance of a post-amputation phantom foot followed a lesion of the opposite parietal cortex. De Gutiérrez-Mahoney¹⁸ has put this theory to the test and carried out resection of the postcentral sensory cortex in a patient with a very disagreeable phantom arm. After two years the result remains a striking success. He has since had another equally satisfactory result.¹⁹ Carmody and Sweet⁶ have just relieved the phantom finger sensation in a third patient after a forearm amputation, but the postoperative period of observation is still too short to be sure of their success. With lesions which involve the corticothalamic connections, as pointed out by Gerstmann¹⁴ and Nielsen,³⁷ the patient may lose awareness that he possesses portions of the opposite side of his body. This is the antithesis of the phenomenon of the phantom limb and gives addition backing for the surgical ablation of the postcentral convolution of the cerebral cortex. Michelson³⁴ has reported five instances which we have observed in the neurosurgical clinic of the Massachusetts General Hospital. In one of these patients a depressed parietal fracture, causing cortical irritation of the postcentral arm area, produced pain very similar to that experienced from a disagreeable phantom to radiate down the opposite arm. By infiltrating the brachial plexus it was possible to obtain a complete motor and sensory paralysis, yet the pain which seemed to originate in her arm remained unaltered.

It is obvious that this projected attack on the highest station for sensation in the cortex is too new to permit any definite conclusions to be drawn, but the theory can be tested by turning down a small parietal bone flap under local anesthesia, then identifying the motor and sensory areas by electrical stimulation and infiltrating the first postcentral convolution with procaine.

5. *Release from States of Agitation and Introspection by Frontal Leucotomy.* A final possible approach to the problem of the unbearable phantom is the elimination of the sufferer's introspection and self-centered concentration on his condition which is the natural outcome of long-standing intractable pain. Ordinary psychotherapeutic methods alone have not been effective, but on theoretical grounds bilateral frontal lobotomy might accomplish this result, as it has benefited so many of Freeman and Watts's patients suffering from agitated states.⁴³ A successful operation of this type has been performed by Lt. Colonel Van Wagenen.⁴⁶ This patient had had a series of forty-five operations for chronic osteomyelitis, ending up with an amputation of the leg through the pelvis. He continued to have intractable pain in his phantom limb and was a confirmed morphine addict. In the year that has elapsed since the lobotomy he has recovered from his drug addiction, is able to look after his house, and has only rare phantom sensations in his amputated leg, which are no longer a cause for serious concern.

Experience with these two operations is limited to three successful cases with adequate periods of postoperative observations. The first removes the sensory cells which may give rise to disagreeable phantom sensations, while the second does away with the subject's introspection and preoccupation with his complaints. In conclusion, it is well to restate that both must still be regarded as purely experimental procedures which will require extensive investigation before their therapeutic value can be estimated. At present neither of

these operations is to be considered except under pressure of extreme suffering and in a patient who threatens, unless relieved, to deteriorate into hopeless invalidism. If successful, they will open up a new method of surgical intervention for heretofore hopeless situations, conditions which cause so much pain and incapacity that the patients either become neurotic invalids and drug addicts or suicides. Every war has produced a new crop, and it is to be hoped that we shall have learned how to relieve the majority of them as one of the few happy by-products of the recent conflict.

SUMMARY AND CONCLUSIONS

1. Pain following injuries to peripheral nerves has been a serious wartime problem. In neuromas with local tenderness and hyperesthesia it is often a cause of prolonged disability. In the severer grades of causalgia and phantom limb pain it may result in prolonged torture with ultimate addiction to narcotics, deterioration of personality or even suicide.

2. The unsatisfactory results of operations for pain complicating nerve injuries in the last war were valuable lessons in what the surgeon should avoid. In dealing with these unstable individuals any unsuccessful surgical intervention can only result in making matters worse. Procedures which are now generally known to be ineffective or even definitely harmful include repeated resection of neuromas, neurectomy or nerve injections at higher levels, posterior root section and re-amputation. While occasional successes have been reported after periarterial sympathectomy, this operation is not effective in the major neuralgias and its results can be duplicated in the less severe cases by paravertebral injection of procaine or by fever therapy.

3. The experience of this war has shown that causalgia and many forms of diffuse hyperesthesia can be treated effectively by sympathectomy. The local tenderness and

discomfort over a mechanically irritated neuroma can often be relieved by its resection, provided that effective measures are taken to prevent reformation. Other varieties of intense aching or lancinating pain centered in the lower extremity generally respond well to cordotomy. The unbearable discomfort of a phantom extremity can be removed by spinothalamic tractotomy, provided the operation is done before the psychic manifestations are permanently engraved on the cerebral cortex. Even under these circumstances there is promising evidence that the phantom sensation can be removed by resection of the sensory cortex, or the patient's concentration of his symptoms released by prefrontal leucotomy.

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IN neurosurgery, as in other fields, the most important diagnostic factors are the careful history and physical examination. Valuable adjuncts, such as perimetry, audiometry, roentgenography, electroencephalography, and cerebrospinal-fluid studies, may be essential.

From "Surgical Treatment of the Nervous System" edited by Frederic W. Bancroft and Cobb Pileher (J. B. Lippincott Company).

THE REPAIR OF PERIPHERAL NERVE LESIONS*

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“WHEN nervous tissue is cut, it does not repair itself neither does it reunite.” This statement was made by Hippocrates and even though his concept of nervous tissue was not precise and he used the term to include tendons, ligamentous structures, and in fact all “white” tissue in the body, one may assume that at some time, he had the occasion to note the failure of an actual nerve to repair itself. We must realize then that the problem of nerve repair is as old as the art of medicine.

A topical survey of the literature on the subject will bring out the fact that the spotlight of attention is focused upon this problem during every war. Medical journals published during the last war were filled with articles dealing with the diagnosis and treatment of nerve injuries.

During that period, the technic of nerve suture was greatly improved and certain principles enunciated: (1) The recovery is better in early repair, however, the recovery in late repair may be good (Delageniere had one case twenty-eight months). (2) Tension at suture line is a serious impediment to recovery. (3) Orientation of stumps with regard to internal topography is essential. (4) The formation of scar tissue in and about suture line prevents recovery. (5) The suture material used must be innocuous. (6) A poor vascular bed for repaired nerve fosters the development of fibrous tissue. At the same time, laboratory experiments were carried out that gave hope in a more radical approach to the treatment of extensive nerve injuries. Huber,¹ Nageotte² and others were successful in using formalin fixed homologous nerve grafts in animals. Their technic was enthusiastically applied to human material, however, there has been no known

instance of the successful grafting of a large nerve trunk.

It is interesting to note that following this period, a lessening of interest in the problem and a wave of pessimism and doubt developed which was in sharp contrast to the ambitious and hopeful attitude of the surgeons of the war period itself, and in spite of the enormous number of nerves operated upon during and following the last war, it is almost impossible today to get a clear picture of the results obtained. In nearly all the series reported, only a small percentage of the cases in which the patients were operated upon were carried to final evaluation. The value of such reports is further vitiated by the fact that the criteria for determining the degree of recovery was not standardized. The following representative reports show the disparity that existed in the records of that time.

One cannot believe that the type of material varied to any great extent or that there was so much difference in the skill of the various surgeons; the difference, therefore, lay either in the selection of the material or in the method of evaluating the results.

It was our problem at the beginning of this war not only to operate upon and repair nerves to the very best of our ability but to see to it that a study of our results would be of some value to others and that the evaluation of our results either good or bad would not be open to questioning. We were fortunate at the time the neurosurgical service was initiated at the Naval Hospital at St. Albans in 1943 in being able to make arrangements for all cases of peripheral nerve injury to be examined by skilled and impartial observers, who not only aided us in the study of the cases but

* From the Neurosurgical Service of the U. S. Naval Hospital, St. Albans, N.Y.

also served as judge and jury in passing upon the final results. We are deeply grateful to Dr. Joseph Moldaver and Dr. Ernest Hertz, of the staff of the New York Neurological Institute and Dr. I. M. Tarlov of the New York Medical College for their tireless cooperation in this work, and to the National Research Council for its support.

In brief, each case study consisted of the following: (1) A neuroclinical examination including sensory, motor and vasomotor evaluation, (2) electrodiagnostic tests with particular emphasis upon chronaxie,¹⁰ (3) sweating and skin resistance tests, (4) microscopic studies giving information as to the condition of the proximal and distal

TABLES

(A) THE SURGEON GENERAL'S REPORT OF THE MEDICAL DEPARTMENT OF THE U.S. ARMY IN WORLD WAR I: END RESULTS OF 400 CASES OF NERVE SUTURE.

Nerve	Good	Mediocre	Negative
Brachial plexus.....	0	100	0
Radial.....	11	66	22
Median.....	12	56	32
Ulnar.....	5	72	22
Sciatic.....	1	60	38
Peroneal.....	0	50	50
Tibial.....	0	50	50

(B) RESULTS OF SUTURES ON PERIPHERAL NERVE INJURIES BY VARIOUS AUTHORS:

	Delag-eniere ³	Jalco-witz ⁴	Ken-edy ⁵	Stop-ford ⁶	Platt ⁷
Total cases.....	142	57	?	271	150
Successful or recovery.....	85.9%	0	73%	90%	79%
Partially successful, Extensive improvement.....	11.2%				
Moderate improvement.....		2			
Failure (or no recovery).....	2.8%	19	27%	10%	21%
		28		16*	

* No recovery recorded in six to thirteen months.

(C) RESULTS OF LOYAL DAVIS:(8)

Nerve	Good	Fair	No Results
Ulnar.....	8	11	1
Median.....	5	3	1
Radial.....	4	5	1
Combined median-ulnar.....	3	4	1
Brachial plexus.....	0	3	4

(D) RESULTS OF SECONDARY NERVE SUTURE AFTER FOERSTER:(9) (CENTRAL EUROPEAN)

Author	No. of Cases	Recovery Per Cent	Good Per Cent	Fair Per Cent	Failure Per Cent
Foerster.....	370	96.0	55.0	42.0	3.0
Stracker.....	147	75.0	13.0	62.0	25.0
Roper.....	84	22.7	6.0	16.7	77.3
Raeschburg.....	414	35.7			64.3
Stoffel.....	127	62.0	23.0	36.0	38.0
Spielmeier.....	100	59.0	23.0	36.0	41.0
Borchardt.....	59	59.3			40.7
Perthes.....	74	66.0			34.0
Lehmans.....	60	39.1			60.9
Mauss and Kruger.....	42	43.0			57.0
Kuozel.....	44	67.7			32.3
Polz.....	18	22.2			77.8
Moro.....	17	82.3			17.7
Hoffman.....	22	81.8			18.2
Herzog.....	16	12.5			87.5
Wexberg.....	57	54.5			45.6
Ranzi.....	31	48.4			51.6
Kakula.....	40	70.0			30.0
Rost.....	24	56.5			43.5
Cassirer.....	78	51.0			49.0
Steinthal.....	40	27.5			72.5
Total.....	1873	60.0			40.0

stumps of the nerves repaired and (5) motion pictures were taken before operation and during recovery.

ULNAR NERVE LESION CHRONAXIE VALUES IN 1/1000 OF A SECOND*

	Preop.	Postop				
		2 Mo.	4 Mo.	8 Mo.	10 Mo.	12 Mo.
Abd. Min. Digits....	20	16	12	7.2	1.2	1.2
1st Dorsal ioteros....	18	18	12	6.8	5.6	3.2
2nd Dorsal ioteros....	12	10	9.2	4.4	5.2	2.4
3rd Dorsal ioteros....	13.2	14	9.2	5.6	6.8	2.0
4th Dorsal ioteros....	13.2	14	9.6	4.8	3.2	2.8
Clinical Recovery Rating.....		0	0	M2	M3	M4
(Normal Chronaxie)	.16 to .30					

* Chronaxie studies of a single case illustrating anticipation of recovery before clinical signs, and continued drop in chronaxie indicating maturation of nerve fibers.

We have great confidence in chronaxie as an extremely valuable diagnostic aid; in our experience it has been more reliable than electromyography and more practical than strength duration curves and stimulus-tetanus ratios. In evaluating our results, we have used a 0 to 5 scale for both motor and sensory recovery. A slight modification of the Oxford scale was used for the motor evaluation as follows:

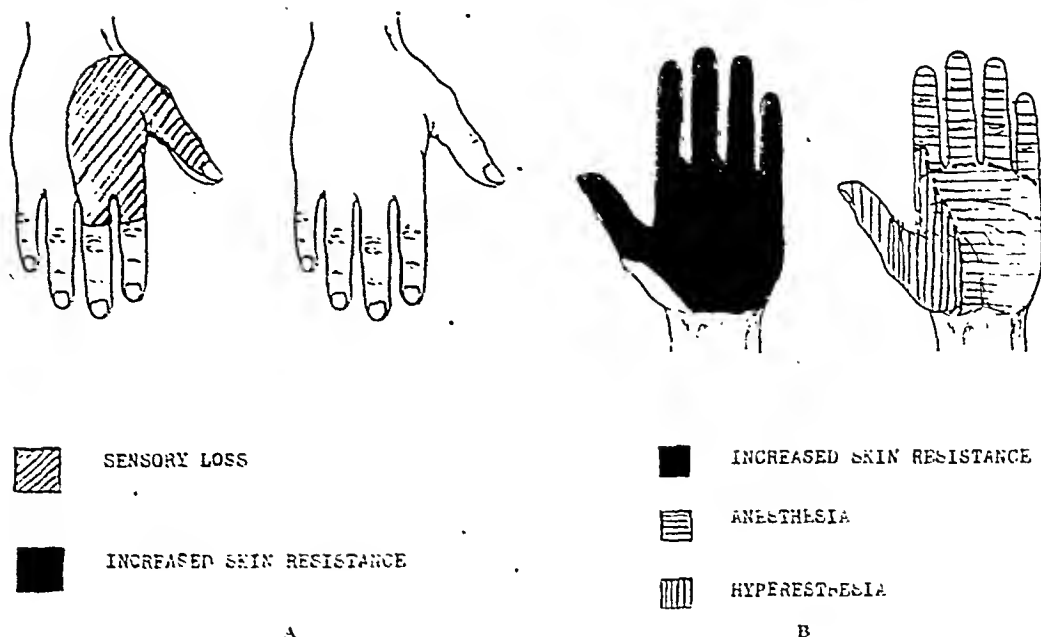


FIG. 1. A and B, two cases illustrating disparity between somatic sensory and autonomic distribution.

- o. No contraction, high chronaxie values.
1. Flicker or trace of contraction or drop in chronaxie.
2. Active movement of some of affected muscles.
3. Active movement of majority of affected muscles.
4. Active movement against resistance, i.e., useful function.
5. Normal power and *all* muscles re-innervated by chronaxie test.

For sensory evaluation, we have followed our own scale:

1. Return of deep pressure sense, often with distributional confusion.
2. Touch and/or pain sense.
3. Distinction of sharp and dull.
4. Localization of touch.
5. Two-point sensibility and stereognosis. (The presence of hyperesthesia or "distributional confusion" drops the rating by one.)

Our findings in the study of skin resistance have differed somewhat from those of Richter and others inasmuch as we find that the distribution of vasomotor fibers does not necessarily coincide with the sensory distribution of the nerve and that their rate of recovery may be very different.¹¹ (Fig. 1.)

As mentioned earlier, the cardinal points

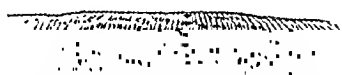
of satisfactory neuroraphy were defined by surgeons of the last war, and we, too, agree that any method of repair which achieves, (1) approximation of nerve ends without tension, (2) accurate orientation of the internal topography of proximal and distal stumps, and (3) retardation of, or at least, no increase in the tendency for ingrowth of scar tissue into the suture line or the encirclement of the nerve and its repair by cicatrix, meets all the theoretical and practical demands of nerve suture. The majority of the neurological surgeons in the service today have employed the epineural suture as was used in the last war, modifying the technic only by employing fine tantalum wire instead of fine silk. The wire seems to have an advantage over silk in that it incurs less foreign body reaction. However, no matter what the suture material, we are of the opinion that the classical epineural suture is bound to encounter certain technical difficulties because the epineurium itself is a structure subject to wide anatomical variations in the case of abnormal nerves. In most cases, the epineurium is thickened which may go on to constricting keloid-like encasement. The epineurium may contract, forcing the protrusion of fasciculi, or, it may stretch allowing the fascicles to retreat within the



Freshly cut nerve



Retraction of epineurium

Theoretical alignment
of fasciculiActual effect of
epineurium suture

Plasma clot fixation

FIG. 2.

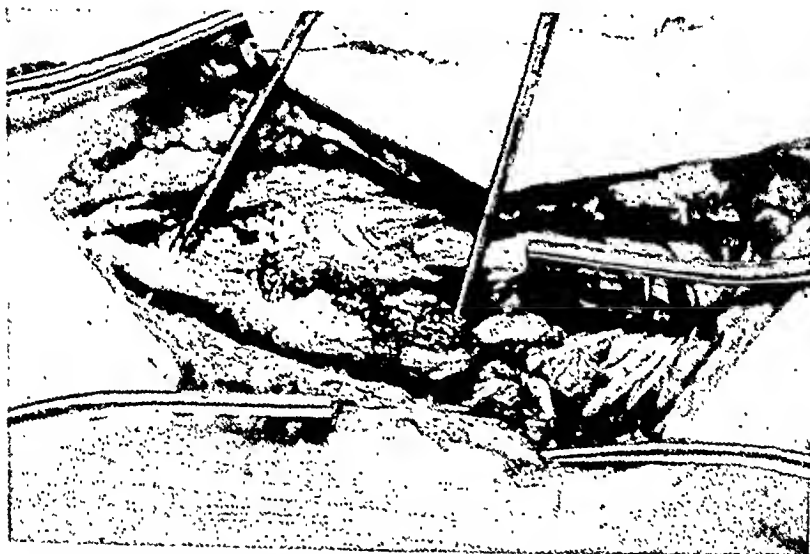


FIG. 3. Radial nerve which had been transplanted and wrapped in tantalum foil. Not injured originally, nerve now shows considerable epineurial fibrosis.

sheath. I have believed that the repair of nerves, by the use of plasma clot, as first suggested by Young and Medowar¹² and the technic for which was later perfected by Tarlov,¹³ overcomes to a great extent the difficulties inherent in the old epineurial suture technic. (Fig. 2.)

The practice of enveloping the repaired nerve in some sort of protective covering such as blood vessel, fat, fascia or cellophane in order to prevent the involvement of the nerve in scar had been tried before this war by many with equally bad results.

It is unfortunate that during the war, a wave of enthusiasm over the newly discovered metal tantalum lead to the wholesale wrapping of nerves in tantalum foil without rational or experimental justification. (Fig. 3.)

Since the organization of the Neurosurgical Service at St. Albans, we have carried out plasma clot repair of approximately 150 nerves. Final evaluation of this series will be the subject of a later communication, but a study of the results so far obtained permit several interesting ob-

servations. The best results were obtained in the group designated as "delayed repairs," i.e., after healing of primary wound, while the worst results were in the group designated "secondary repairs," those cases which have had one or more previous attempts at repair. The rate of recovery varied enormously, three cases showed evidence of reinnervation in eighteen, twenty-one and twenty-eight days, the most rapid being a facial and the next two median nerves. None of these were cases of "early repair." Very complete final recovery has occurred in some cases in which no evidence of reinnervation was detectable for nine months to one year after repair. The factors determining rate of recovery are not known.

Five nerve grafts were attempted, three of these were fresh cadaver grafts and two autogenous cable grafts. In none of them has there been any evidence whatever of axonization of the distal end of the nerve. Re-exploration of the graft in two cases allowed for stimulation of the graft under local anesthesia and it appeared that neurotization of the graft had occurred for a distance of 2 cm. from the suture line but that beyond this point the graft was completely fibrosed without evidence of axonization. (Fig. 4.)

Clinical experience with nerve grafts is in sharp contrast with the results obtained in laboratory experimentation, where in many cases both clinically and histologically a complete reinnervation of the distal end of the nerve occurred.¹⁴ In consideration of nerve grafts, certain factors should be clearly understood. In the first place, the completely successful nerve graft would suppose that the Schwann cells continued their existence as in a tissue culture when transferred from the donor to the host and in order for them to do this rapid re-vascularization of the graft must occur. Histological studies of re-vascularization of nerve grafts in animals¹⁵ show that each end of the graft receives outgrowing blood vessels from the adjacent nerve stumps but

that the central portion of the graft receives its blood supply from the contiguous tissue. The first requisite then for a graft to succeed is that it be placed in a well vascularized bed. The very fact that a nerve graft is needed, that is to say, that there has been a gross loss of nerve substance, implies that there has been considerable destruction of soft tissue and that the possibility of obtaining a vascular bed for a nerve graft is a remote one. In our own cases, it was obvious that the first two grafts were placed in fibrosed avascular beds in which their chance for survival was indeed remote. In our next two grafts, an attempt was made to overcome this obstacle and the epineurium of the graft itself was split and opened up like the hood of a cobra. After attaching the central stump of the nerve to one end of the graft, this "cobra hood" was then reflected back over the belly of a normal adjacent muscle with each separate nerve fascicle in direct contact with the muscle surface. It was hoped that this would allow the graft to become vascularized and neurotized, and at a second stage, be reflected from its muscle bed and attached to the distal end of the nerve. However, at re-exploration after one year in this position, it was found that the graft had become replaced by fibrous tissue with mature neurotization of only the proximal centimeter of the graft.

The use of autogenous cable grafts from every point of view is more apt to be successful, since it eliminates the factor of anaphylactic destruction; but where grafts are needed in large defects, the amount of material needed is so great and entails the sacrifice of so many small cutaneous nerves, that again the procedure is impractical. We know that grafts of small dimensions do and will succeed and this is of great importance in certain and specific instances, particularly in the facial canal and in the fingers where no amount of mobilization of nerve ends is possible and where even a graft of a half a centimeter is of real value. In large nerves of the

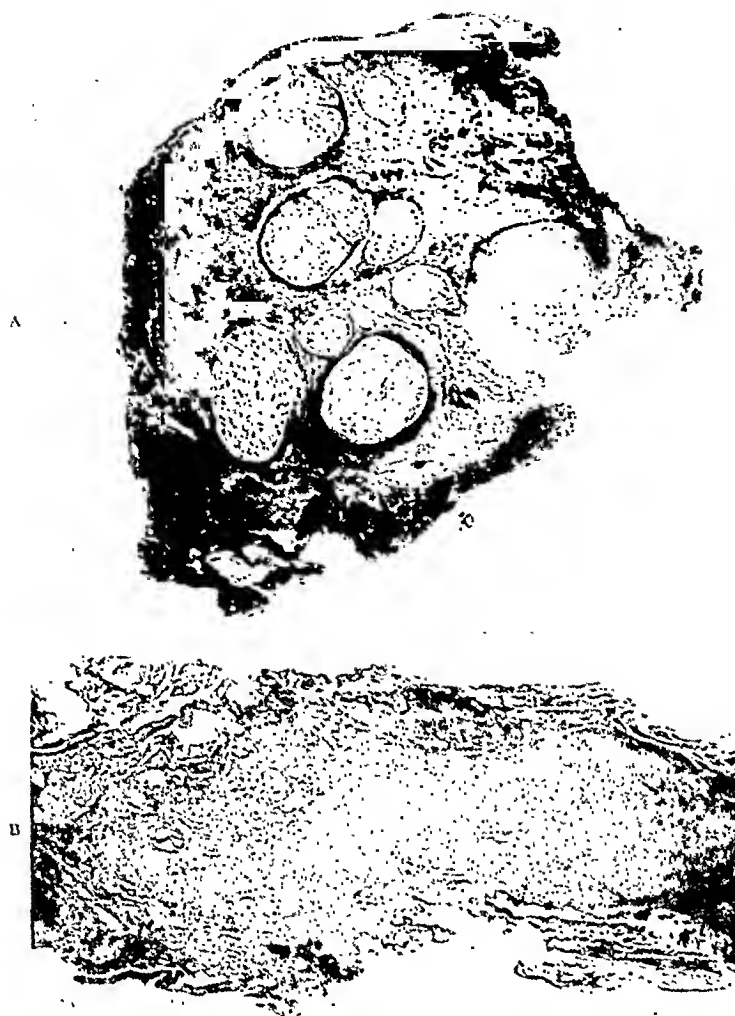


FIG. 4. Low power microscopic section showing good fasciculi central to graft (A), and complete fibrosis of graft (B).

extremities, however, where mobilization, transplantation and angulation of adjacent joints can be made to contribute as much as 8 or 10 cm. of nerve available to fill a gap of corresponding length, the use of short grafts is of no value. It is interesting then that at the close of the last war at a time when there was much enthusiasm for the use of grafts, Naffziger¹⁶ decried the profligate use of grafts and stated clearly that the necessity for grafting could be reduced to a minimum by the radical employment of transplantation, mobilization and angulation. In 1927, Babcock re-emphasized this fact.¹⁷ Naffziger also stated that he believed that nerves were capable of surviving a considerable amount

of stretching and that, if necessary, operation should be done in two stages in which the nerves were first fixed together by a so-called end bulb suture and the limb allowed to extend stretching the nerve, so that at the second operation the ends could be amputated and approximated. One case in which we employed this procedure was entirely unsuccessful. At reoperation, the central stump was found to contain fascicles of nerve fibers but the distal stump had shrunk to one-sixth the diameter of the central stump with complete loss of internal topography and collagenization of the remnants of the Schwannian tubes.

It is fair to assume that both central and distal segments of the nerve had been

subjected to the same or nearly the same tension, but it is obvious that the distal end was destroyed by this stretch while the central stump was relatively unaffected.

We have in our series, six cases of plasma clot repair in which there was complete failure of reinnervation of the distal stump. In all six, an attempted repair at a previous operation by an inexperienced operator had resulted in the suturing of a central tendon to the distal stump of the nerve, and in these cases the constant tugging of the tendon on the distal stump had led to complete fibrosis of the distal end not only at its point of attachment but throughout the extent of the nerve. We, therefore, reached the conclusion that the distal stump of a severed nerve will not tolerate stretching. The central portion of a severed nerve, however, is a normal structure with normal blood supply and it should have normal ability to withstand stress and strain. The work of Denney Brown¹⁸ describing the early and late changes that follow sudden stretching of nerves in animals is not in conflict with our idea, that the central end of a nerve will tolerate gentle but prolonged stretching. These observations have lead us to attempt a procedure which we call a two-stage stretch operation and which we have employed instead of nerve grafts. The technic for this procedure will be described in another communication.

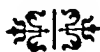
SUMMARY

The importance of exact and detailed methods of evaluating nerve deficit, and the careful recording of all factors which might influence nerve recovery is empha-

sized. In our hands the plasma clot repair of nerves has seemed to offer definite advantages over other methods of repair. We believe that the unavoidable obstacles to successful employment of grafts limits their use to small nerves and peripheral branches. Gentle and prolonged stretching of the central stump may be the answer to bridging the gap of major trunks.

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Film Previews

OPERATING ROOM TECHNIQUE*

A SERIES of motion pictures entitled, "Operating-Room Technique," depicting the application of aseptic principles and the duties and organization of work among operating room nurses in preparation for and during operative procedures was prepared to provide a visual media for the education of surgical nurses. Films included in the series are as follows: Setting up an Operating Room, Duties of the Suture Nurse during the Opening and Closure of a Celiotomy, Preparation and Draping of Operative Areas, and Care and Handling of Sutures.

These were prepared in collaboration with Edythe Louise Alexander, Supervisor of Operating Rooms, Roosevelt Hospital, New York, and are available for distribution through the D&G Surgical Film Library. They may be obtained in 16 mm. sound or silent, color film. When the silent film is requested, printed commentaries are provided, supplementing the titles of the picture. The picture was prepared by Davis & Geck, Inc., Brooklyn, New York.

* Courtesy of Davis & Geck, Inc.

The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-fifth Year of Continuous Publication

VOL. LXXII

OCTOBER, 1946

NUMBER FOUR

Editorial

THE FENESTRATION OPERATION

MAJOR HAZARD—THE ANESTHETIC

RECENT interest in the fenestration operation has focused attention upon an operative area of a few square millimeters. In an effort to provide ideal conditions for this field, methods of pain control are employed which constantly endanger the life of the patient. An attempt has been made to by-pass general anesthesia, a nuisance to be avoided, substituting for it analgesia and anesthesia by massive doses of barbiturates and opiates.

The novelty and the glamor of the new procedure seems to have deprived it of the wise and prudent approach common to anesthesia for the usual throat and ear surgery. Who, for example, would consider prescribing 9 gr. of barbiturates and $\frac{1}{2}$ gr. of morphine for a radical mastoid operation? Who would tolerate, or be responsible for, postoperative respiratory depression lasting from eight to twenty-four hours for the ordinary nose and throat operation? As might have been anticipated, serious respiratory depression has already been reported.

The following notes are submitted from case reports: in Case 1, nembutal gr. 9, and morphine gr. $\frac{1}{2}$ were administered and perfect analgesia was obtained for operation. During the night, however, respira-

tions dropped to 2 per minute, requiring expert administration of oxygen, coramine and metrazol until recovery. In cases 2 and 3 both very large men, the first received 1 gr. of morphine before and during operation. He could scarcely be kept on the table. The second received $1\frac{1}{8}$ gr. of morphine. Despite repeated novocaine injections he cried and fought constantly. The operation could scarcely be completed. Both patients exhibited respirations of six or seven a minute and required the constant attention of doctors and nurses for twelve hours. The patient in Case 4 was given nembutal gr. 9, neonal gr. 3, morphine gr. $\frac{2}{3}$ and required stimulation for three days to overcome the depression which developed (first night respirations 4, second day 12, gradual recovery on third day). Case 5 illustrates the danger of intravenous pentothal. The patient received $2\frac{1}{2}$ gm. of pentothal over a period of one hour and forty minutes and was unconscious for three days. The temperature rose to 104°F . postoperatively; the patient was restless and respirations were depressed until recovery. Case 6 indicates the handicap with endotracheal cyclopropane. Oozing was so general and so severe that only the mastoid operation could be done. The fenestration procedure

was done under a local anesthetic at a later date.

Why, it may be asked, has sedation been urged and general anesthesia avoided? Because general anesthesia means venous congestion and increased bleeding into a wound where hemostasis is essential? Because general anesthesia is thought to imply a prolonged and unpleasant post-operative period? Because general anesthesia, under good control and with the minimum after effects, implies expert service which is expensive and difficult to procure? It is not easy for one patient to pay for anesthesia for a whole morning or for an entire afternoon (two to three hours).

Because of these real difficulties, oral and hypodermic medication, supervised by anyone who happens to be available is a natural result. One attempt has been made to diminish the hazard of massive sedation. Demoral has been substituted for morphine. Experience will prove whether demoral can replace a general anesthetic for surgery involving the periosteum and provide a perfectly quiet field of operation.

Although fenestration surgery does not offer the anesthetic difficulties peculiar to abdominal, thoracic and brain surgery, it does most certainly line up to the general requirements of all general anesthesia. These requirements are: safety, control of the field and comfort for the patient.

The therapeutic index of sedative drugs prescribed by pharmacology, toxicology and clinical medicine must be respected. These indices cannot be cheerfully disregarded because a new type of operation holds the spotlight. The therapeutic index of nembutal (therapeutic breadth, or difference between anesthetic dose and lethal dose) is narrow, 1.5. Clinicians and anesthesiologists know that the routine use of even $\frac{1}{4}$ gr. of morphine sulfate occasionally results in grave respiratory depression. Massive sedation, by causing relaxation of the muscles of the airway, induces respiratory obstruction. This obstruction is increased by torsion and flexion of the head.

Control of the respiratory airway is seriously embarrassed by the sterile head drapes covering the patient.

The surgeon, intent upon his field of operation, regards attempts to relieve obstruction as an unnecessary delay, an annoyance to be tolerated rather than cooperation for which to be grateful. As a consequence moderate obstruction is usually ignored, marked obstruction is permitted, and it is only when obstruction becomes acute that anything is done about it. If it were not for the reflex pain stimulating the respiration, asphyxial accidents would be common. Returned to bed, the patient's recovery from sedation is prolonged and is often the occasion of deep anxiety for the nursing personnel.

An experience of twenty years has convinced the author of the safety of the following sequence: Gas-oxygen Ether, preceded (recently) by nembutal gr. $1\frac{1}{2}$, or avertin mg. 70, or demoral mg. 50. Following the relaxation under ether, direct laryngoscopy is performed and the patient is intubated. Anesthesia is maintained by ether at any desired level. Because of the bleeding which is prone to accompany gas-oxygen maintenance, and because of the fire, the bleeding and the circulatory hazard of cyclopropane, the author has eliminated these agents in his practice.

Once the patient is intubated, the respiratory hazard is by-passed completely and permanently. Anesthesia is easily controlled at any desired level with a low percentage of ether. The head may be flexed or rotated to any degree without influencing the freedom of respiration through the endotracheal tube. Intubation under ether relaxation by endotracheal tubes modified from Jackson's bronchoscope have produced no trauma and no bleeding, (hoarseness .05 per cent) in the author's hands.

In answer to queries concerning the postoperative symptoms which may be expected in ordinary laryngoscopy and intubation, the following is quoted from a letter received from the clinic of Dr.

Chevalier Jackson: "In reply to your letter of December 1st (1945) regarding reactions to bronchoscopy, neither Father nor I feel that there has been enough 'sore throat, hoarseness, tracheitis, or bronchopneumonia' in the experience of our clinic, to merit even a mention. Of course, much depends upon the techniques used in these procedures, but we are firmly convinced that with reasonably careful technique and due consideration for the contraindications, bronchoscopy in itself is entirely without harmful effects." If to this experience of the Jackson Clinic is added the fact that laryngoscopy and intubation for anesthesia is a less severe procedure than bronchoscopy, and that it is carried on in a relaxed field, the hazard is acceptable.

By adhering to ether relaxation and the gentle introduction of sterile *metal* endotracheal tubes of the correct size, consistently satisfactory results may be anticipated. A properly relaxed patient will permit exposure and non-traumatic intubation, with one attempt, in less than a minute. For those who have never learned to give ether or who have forgotten how, intubation is frequently a hazardous adventure for patient and anesthetist. Deviations from the technic recommended, that is, exposure under various gas combinations, local pentothal, etc., by direct or blind intubation, is followed by frequent regrets.

Since analgesia and anesthesia by massive medication is irreversible (a dose once administered cannot be removed), the patient's response to pain is awaited as an indication for further dosage. This means that trouble always develops before it can be relieved. Moaning, straining, movement and holding the breath result in venous congestion and ooze, and the operating time is increased in an effort to control this ooze.

On the other hand, absolute and complete control is secured by endotracheal anesthesia. The field is silent and entirely motionless. Because there is no straining, and because respiratory ventilation is complete, venous stasis is eliminated.

Bleeding in the field is arterial. This arterial bleeding will necessarily depend upon the normal blood supply to the part. While full sedation may be safely employed with the protection offered by endotracheal anesthesia, attempts to depress the general circulation by additional medication is certainly to be condemned. The patient's life is more important than an absolutely bloodless operative field. Furthermore, as in other types of head surgery, hemostasis may be aided by lowering the feet and the body, and by adrenalin packs allowed to remain for some minutes in the field.

The general anesthetic sequence recommended will not be as pleasant as in massive medication. Occasionally, a patient will complain of postoperative illness. The majority of cases of postoperative illness are due to anoxia rather than to the odor of the anesthetic; however, the patient as well as the surgeon, unfamiliar with endotracheal ether anesthesia, will be surprised by the rapid and smooth convalescence when a protracted postoperative illness was expected. Suitable preoperative medication allays apprehension and small doses of postoperative sedation provide comfort.

Therefore, the popularization of massive sedation as a substitute for general anesthesia in the fenestration operation endangers the life of the patient and prolongs the operative procedure. Bleeding in the field occurs from venous ooze and from arterial blood. Venous ooze is increased in respiratory obstruction and during spasm or straining from periosteal pain in which massive sedation is used. Sedation (barbiturates up to 9 gr. and morphine gr. $\frac{1}{2}$) requires prolonged and careful postoperative nursing to prevent asphyxial accidents. Safety is assured and venous oozing is eliminated by a properly conducted general anesthesia with ether carried on by the endotracheal inhalation technic without carbon dioxide absorption. Well selected, small doses of preoperative and postoperative medication provide comfort for the patient. The employment of this technic will prevent asphyxial deaths.

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Original Articles

IMPORTANCE OF SULFHYDRYL IN THE TREATMENT OF CORNEAL AND X-RAY BURNS

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A SUBJECT of major concern to the ophthalmologist or surgeon is the after-scarring of burn patients. He is never permitted to lose sight of this possibility as evidenced by the patient's query: "Doctor, will it leave a scar?" Such anxiety on the part of parents reaches its peak when the patient is a child.

This question of scarring may not be confined to one of purely cosmetic considerations but, as every surgeon knows, may result in long and tedious plastic surgery at best, or at worst provide a field for malignant growth in occasional cases.

For this reason every method is sought to bring about healing of burns and wounds in the shortest possible space of time. Undelayed healing is a goal worth seeking for prevention of after-scarring as well as for other practical reasons.

Reference has been made to the fact that "Chronic granulation tissue is the parent of scar tissue, and it might be added the longer the wound takes to heal the more the scar tissue."¹

A study based on five years of clinical application in more than 500 cases of burns, involving the eyes and adjacent areas provides a basis for hope that the danger of after-scarring may be greatly reduced. The therapy used in this study has produced healing without leaving scars or contractions in most cases. In the remainder any scarring was deemed to be considerably less than ordinarily might be expected. In no case was there evidence of development of symblepharon.

Available evidence points to the likeli-

hood that this happy result is achieved by employing therapy that is capable of stimulating cell activity and producing healing in the shortest possible time. The clinical evidence appears to substantiate the biochemical aspects fully indicating that sulfur in an available form is capable of stimulating certain sulfur-containing amino acids present in the body and known to be concerned with tissue oxidations. In the study reported here the therapy used provided a high concentration of sulfhydryl* in an aqueous solution that is non-toxic and safe to use as drops directly in the eye in appropriate dilution, as well as orally and topically.

Adoption of a safe, non-toxic, available sulfur for the treatment of eye burns and possibly other eye conditions is indicated by extensive literature referring to the importance of sulfur-containing compounds in the eye. This is also true for other parts of the body.

X-RAY BURNS—CRITICAL TEST

The critical test for any treatment for burns might well be said to rest on the question: "How does it differ from any of the other 100 or more methods presently advocated?"

After five years of routine use combined with a search of the literature and an evaluation of clinical and laboratory studies by others, we are prepared to say that hydrosulphosol differs from other medications in

* Hydrosulphosol—a proprietary epithelial stimulant containing sulfhydryl pentathionate. The Am. Illus. Med. Dict., Dorland, 20th ed., Philadelphia, 1944. W. B. Saunders Company.

important and essential respects. Undoubtedly, an outstanding feature of this treatment is the fact that it has demonstrated in the hands of three different workers ability to stimulate tissue activity and bring about healing in x-ray burns. Here we are faced with a condition that has not merely resulted in a burn but an injury that leaves the underlying tissue devitalized.

In the presence of infection or poor physical condition of the patient, both of which retard or block healing of the wound, hydrosulphosol has elicited a long-sought chemotherapeutic response by promptly stimulating cell activity and bringing about healing in an incredibly short period of time.

Particular emphasis is placed, therefore, on one of the leading cases presented herein. This case involved a suspected malignancy complicated by a severe x-ray burn. (Fig. 1.) Radical surgery was avoided and recovery from x-ray burn effected in about three weeks. A brief case report is presented herewith on this patient.

Mrs. D. T., age forty-six, a married woman, had a past history of smallpox, typhoid, and influenza in 1918. Three years ago she had had her lower teeth extracted. The upper teeth were checked routinely. Her general condition was good with no headaches. Following a blow caused by being struck in the inner corner of the right eye by a door, an indurated skin lesion appeared just below and medial to the right orbit. Failing to effect healing by application of home remedies, the patient consulted her family doctor who diagnosed the condition as skin cancer and ordered x-ray treatment given. Twelve x-ray treatments were given by another doctor in the hospital.

X-ray treatments were followed by severe pain which gradually subsided after each treatment. After the twelfth treatment inflammation did not decrease. Radical surgery involving excision of affected tissue was considered when the patient was referred to me for consultation and treatment.

When first seen by me the area of scar from the x-ray treatments was broken down and practically devoid of blood vessels with an inflamed area extending along the right side of the nose to the right eye. This area was

approximately 4 by 5 by 3 mm. just external to the right lacrimal sac area. The right eye watered continuously due to obstruction of the tear ducts by scar tissue. The area was quite painful to the patient. A smear and culture from this area showed presence of *Staphylococcus albus* infection. Kahn test and Wassermann reactions were negative.

Treatment was instituted with hydrosulphosol to attempt to clear up the x-ray burn. The patient was put on almost continuous application of warm hydrosulphosol packs both at the office and home. The pain and burning sensation cleared rapidly and after about six days scar tissue began to slough and there appeared to be a clean wound, the edges of which showed beginning of granulation tissue. At the end of ten days small islands of epithelium were present which spread gradually and the area was completely healed in about three weeks. The patient is seen occasionally and after eighteen months there has not been any breakdown or recurrence of original condition.

OLD X-RAY BURNS

The action of hydrosulphosol in a case of delayed x-ray burn, reported by MacDonald,² is suggestive of the wound healing possibilities of this product. In this case, widespread ulceration had finally supervened fifteen years after low voltage x-ray treatments and had led to the development of multiple telangiectoses, extending on both sides from Poupart's ligament to the heels. The biopsy showed the characteristic lesions of the x-ray both in the obliterative endarteritis in the floor of the ulcer and the precancerous changes in the epithelium.

The fact that the largest ulcer whose area was 48 sq. cm., continued to spread under a variety of accepted treatments whose duration covered more than a year, and, after three weeks of hydrosulphosol one-half of its area became covered with new epithelium and complete healing eventually took place, is exceedingly suggestive. In addition, the lesion was badly infected with *Staphylococcus aureus* and *Bacillus pyocyaneus*. Prior to use of hydrosulphosol amputation was being considered in this case.

Reinforcing these cases is the personal experience of Strong.³ As one of the pioneers in development and use of x-ray, Dr. Strong sustained severe x-ray burns on the left hand, the result of cumulative exposures with development of a spreading epithelioma of the left wrist. After years of ineffectual treatment utilizing known methods calculated to assist repair of such lesions, Dr. Strong employed hydrosulphosol therapy immersing the hand in dilute soaks, applying it in wet compresses and finally as a lotion using full strength solution. Under the influence of hydrosulphosol therapy regenerative changes began and within six months the lesions entirely disappeared. Today, after more than five years there has not been any breakdown of tissue or evidence of any action other than establishment of complete healing.

One explanation of these remarkable results is suggested by the chemical composition of the product and its indicated relation as a nutritional factor in the skin itself.

SULFUR IN THE SKIN

Sixty per cent of the sulfur in the body is contained in the skin.^{4,5} Harkins⁶ recommends "sulfur to promote epithelization."

A sudden loss of sulfur in the skin and disturbance of sulfur metabolism caused by a serious or extensive burn has implications beyond that of a mere surface injury. As pointed out by Klauder and Brown,⁷ "it appears that the skin acts as a depot of sulfur on which demands are made as part of the defensive mechanism operative in infections and intoxications." Thus it would appear that at one stroke the body can be rendered vulnerable in two important aspects by a burn injury. First, the skin and tissues suffer an injury to the chemical mechanism that is directly concerned with tissue respiration and repair. Secondly, important body functions that rely upon sulfur stored in the skin to supply a stimulus to organs concerned with detoxication and elimination of waste products, suddenly find the source of emergency supply tem-

porarily exhausted. Every surgeon who has treated burns recognizes the dangers of infection, toxemia and other complications that can develop for a patient with an extensive or serious injury of this nature. Biochemistry recognizes and confirms the importance of sulfur in this situation. The problem has been to find a chemotherapeutic agent that measures up to the known requirements. Ten years of study and use of this product indicate that hydrosulphosol provides a practical as well as scientific approach to this problem.

An entirely new concept of the probable value of sulfur therapy in treating serious burns is suggested by Croft and Peters⁸ who found that the sulfur-containing amino acid methionine, protects against decrease of protein by preventing or abating the depletion of nitrogen through the urine.

They state that similar losses in animals were noted in patients as long as ten days after the burn. Reference is made to the fact that the absorption of the free amino acids themselves is much more rapid than of the amino acids as gradually liberated in the gut by digestion from a protein. By way of further explanation these workers state: "One possible hypothesis to explain the benefit of increased protein intake is that the loss of N in the urine is due to the raiding of the tissue protein for one or two amino acids particularly needed for formation of new skin protein, and the elimination of the N from the unwanted amino acids of the tissue-protein molecule through the kidneys as urea. This led us to examine the effect of the sulfur-containing essential amino acid methionine, and also of an amino acid mixture, and of alanine and cysteine."

SULFUR IN THE EYE

The importance of maintaining or stimulating function and activity of glutathione, particularly in the lens of the eye, is suggested by the work of Mackay and co-workers⁹ who report almost half of the total ash (45.8 per cent) of the normal lens consists of sulfate. A considerable portion of the sulfate recovered from the ash is

stated as probably arising from the combination of cysteine, glutathione, and other sulfur-containing organic compounds. Study of the mineral content of the eye shows that practically all of the minerals found elsewhere in the body are evident, but potassium and sulfur predominate.

Elvehjem and associates¹⁰ in their classical work on respiratory enzymes emphasize the importance of the —SH groups (sulfhydryl) in glutathione with the observation that: “. . . it is the sulfur group alone which is of importance in connection with tissue oxidations.”

Kogel¹¹ advances the suggestion that cataract patients be treated with sulfhydryl compounds because of their ability to transfer oxygen.

OXYGEN UPTAKE

The normal lens is capable of appreciable oxygen uptake and the importance of oxygen is pointed out by Bellows¹² who states: “The most vital requirement of any tissue is to secure at all times an adequate oxygen supply.” In case of injury to the capsule there is a striking increase in respiration. Bellows also refers to the work of Mashimo¹³ who reported that a normal rabbit lens requires 6 to 9 cu. mm. of oxygen per hour, whereas with a torn capsule the consumption more than triples (23 to 32 cu. mm. per hour). Similar findings were obtained by Schmerl.¹⁴

The vital rôle played by glutathione is pointed out by numerous workers who confirm the presence of this material in all fresh animal tissues in which the concentration roughly parallels the intensity of metabolic activity.

Reis¹⁵ observed that sulfhydryl disappears in mature senile cataract. This was confirmed by Jess.¹⁶

Adams¹⁷ and Rosner et al.¹⁸ show that glutathione and a protein “thermostable residue” apparently contribute to the normal mechanism for most of the oxygen uptake of the lens.

Thus the employment of a safe therapy that is believed to be capable of increasing oxygen uptake and stimulating the activity

of glutathione would appear to warrant use in treating burns and certain pathological conditions in which such therapy may be indicated.

HEAT DECREASES GLUTATHIONE

Adams¹⁷ reports that the effect of heat produced a significant decrease of lenticular glutathione content.

While emphasis has been placed on the importance of glutathione in its respiratory function Krause¹⁹ believes that protein synthesis may be dependent upon glutathione. This same opinion has been expressed by others.

Work by Bellows and Rosner²⁰ refers to the fact that “changes in the capsular permeability are intimately associated with the state of nutrition of the lens. A decreased permeability would offer a barrier to the normal interchange of nutrients and waste materials, which in turn could cause lenticular changes due either to deficiency of vital constituents or to an excess of a toxic compound. The reduction of glutathione in the cataractous lens is illustrative of this mechanism.”

The detoxifying action of cysteine on naphthalene is pointed out by Bourne and Young.²¹ “One of the Important Functions of glutathione is the protection of ascorbic acid against oxidation,” according to Elvehjem et al.¹⁰

Thus we see in glutathione a material that plays an active and important rôle in maintaining the normal function of the lens of the eye and protecting it as far as possible against damage from injury or decreased body resistance. This same mechanism is referred to as of equal importance in other parts of the body.

It might well appear from a review of the literature that of all factors concerned with maintaining normal function of the lens of the eye sulfur may be the most important. Repeated reference to the rôle played by glutathione and sulfhydryl with an extensive bibliography on the subject is made in the very fine presentation by Bellows¹² in his book on “Cataract and Anomalies of the Lens.”

In addition to the favorable outcome and prompt response to therapy noted in eye burns there has been an indicated value for employment of hydrosulphosol observed in the treatment of corneal ulcers.

Because of the difficulties presented in attempting an evaluation of a treatment on the basis of stimulating healing of injured tissue in man at a rate beyond what might be termed normal, a comparative analysis has been drawn between patients treated previously by other methods, also healing times reported by others when using other methods, and the actual healing time when using hydrosulphosol plus the previously mentioned lack of scarring. This comparison is deemed to be strikingly in favor of the sulfhydryl compound.

A natural and logical basis for consideration of a new medication or therapy is the constant search for methods of treatment that will be an improvement over others that are available or, when used with indicated medicants will speed recovery and improve end results. In the case of treating eye injuries, particularly burns, the local treatment applied to other parts of the body are seldom suitable to use in or near the eyes. The product used in this study proves an exception and certain experimental data compiled in connection with treatment of burns on the skin adds confirmation of important aspects considered in relation to treating eye burns.

The most common type of eye burn may cause searing only of the epithelium of the cornea. The normal healing rate in such cases might be regarded as rapid even when pain-relieving agents are all that are employed. But it is obvious that any treatment that will speed up healing time is deserving of consideration. In the cases of more severe burns in or about the eyes this factor becomes increasingly important.

The use of hydrosulphosol was started five years ago after investigation of the chemical composition of the product and of clinical and laboratory studies reported by workers at the Institute of Pathology, the Western Pennsylvania Hospital, Pitts-

burgh, at the University of California, Los Angeles, and others.

HIGH CONCENTRATION SULFHYDRYL

Salle reported²² that hydrosulphosol contains a high concentration of sulfhydryl (approximately fifty times as much as in human blood). McBroom²³ reported encouraging results in a laboratory study using volunteers from the Research Institute Staff on whom experimental burns were produced by controlled exposure of small areas on the arms to ultraviolet radiation.

Pierce reported preliminary clinical studies²⁴ which were added to by a series of sixty-five cases, results of which are unpublished.²⁵ Mellon reported²⁶ on clinical and laboratory aspects relating to (1) lack of toxicity of hydrosulphosol when administered orally or applied topically, (2) indication of absorption of sulfur in some form and increased elimination of sulfate through the urine, (3) suggested possible enzymatic action of the —SH (sulfhydryl) linkages, (4) stimulation of certain host tissues by an increase in oxygen uptake, (5) more stimulation of cell function and the differentiation that connotes healing, than cell-multiplication only, (6) evidence based on tissue culture studies that not only does normal growth occur, but in dilutions of 1:500 to 1:1000 an important function of chick-heart embryo fibroblasts undergoes marked stimulation. "This function is the proteolytic one, whose differentiating, and therefore healing, connotations align themselves with the clinical expressions in this connection."

Striking response in the treatment of eye burns has been reported by this writer²⁷ also further studies in relation to the importance of sulfur metabolism and results obtained in treating burns of the ear, nose, mouth and adjacent tissues.²⁸

The pH of hydrosulphosol, approximately 10, is lowered on dilution and rapidly reaches levels consonant with tissue function when applied to injured tissue. Confirmation of this action was reported by Williams and Bissell²⁹ who applied a 1:4



FIG. 1.



FIG. 2.



FIG. 3.

FIG. 1. Mrs. D. T., x-ray burn on right side of nose. Healing complete in three weeks without scars and without requiring surgical intervention.

FIG. 2. Face burn; gas oven explosion. Home remedies used for four days prior to consulting doctor. This picture taken start of hydrosulphosol therapy. No bandages applied; patient went about normal household duties.

FIG. 3. Same as Figure 2, ten days after start of hydrosulphosol therapy. No scars due to burns. Completely healed on tenth day with sulfhydryl treatment.

dilution with a pH of 9.5 to clean wounds on experimental animals and found a drop in three minutes to 7.9-8.1.

MULTIPLE CORNEAL ULCER

A second report in our series is presented herewith and relates to treatment of multiple corneal ulcer:

Miss J. L., age fourteen, came for treatment with severe pain in the left eye, stating that seventeen days before her eye became inflamed and painful. The patient was treated by a local doctor in town about 100 miles from Phoenix with several different types of medication without any improvements. Several days before being examined by me the patient stated that the whole cornea, with exception of small area in the upper central portion, became one mass of ulcers and vision was very poor. The patient's doctor telephoned me that it might be necessary to enucleate the left eye. The patient was first examined by me late in the evening of March 5, 1945. She was in extreme pain and it was necessary to administer a hypo to relieve pain.

Examination showed vision was limited to hand movement at three or four feet. Examination of the left eye showed extreme inflammation with ulcers occupying most of the central portion of the cornea and extending both nasally and laterally and to the lower portion of the cornea, but not involving the upper portion of the cornea. There was pus in the anterior chamber and there were some synechiae present. Smear and culture showed pneumococcal infection.

The patient was sent to the hospital and a sub-conjunctival injection of penicillin (250 units to the cc.) was given in the temporal nasal and lower bulbar conjunctiva using enough solution to bulge this membrane so that it was difficult for the lids to close. She was also given 30,000 units of penicillin intramuscularly with 20,000 units every four hours night and day until more than one million units had been given. Other treatment consisted of drops of hydrosulphosol (1:40) together with hydrosulphosol ointment at the corners of the lids which were quite inflamed. At the end of twenty-four hours her pain began to be much less and she was able to sleep without resort to opiates.

By the third day the pus in the anterior chamber was absorbed and the central portion of the cornea began to be more clear and the eye much less painful. The posterior synechiae were broken up by atropine 2 per cent together with a sub-conjunctival injection of 1:1000 adrenalin.

At the end of two weeks the patient's eye was entirely free from pain and ulcers healed leaving, however, a large central corneal opacity which extended over the central and lower paracentral cornea. The patient was able to leave the hospital and come to the office for treatment where hydrosulphosol 1:20 was applied in compresses and 1:40 as drops in eye. Later on hydrosulphosol packs were used from time to time to aid in stimulating absorption of corneal scars.

The patient was sent home and returned from time to time for treatment and check-up. At the end of one year the patient was refracted and with proper correction was able to read 20/40 for distance and was able to read the Jaeger No. 2 line for near. The scar was practically invisible to anyone standing two feet away.

FAST HEALING

By way of illustrating the possible rapid response produced by prompt and intensive application of hydrosulphosol reference is made to a fifteen year old girl treated in our office. This girl received a direct blow in the eye from a hot curling iron. When first seen, approximately thirty minutes after the accident, the central part of the cornea was covered with a white exudate. The initial excruciating pain was controlled with anesthetics and irrigation of the eye started with drops of hydrosulphosol solution in a 1:40 dilution of warm triple distilled water. Instillation of these drops was repeated every half hour. In addition, a 1:20 dilution of hydrosulphosol in slightly warm distilled water was applied continuously in wet packs placed over the eyelids. This treatment was started at about 10:30 A.M. and by 4:00 P.M. of the same day the exudate covering the central cornea had entirely disappeared. At 5:00 P.M. examination of this area under slit lamp showed a practically clear cornea. Subsequent treatment

consisted of occasional instillation of dilute (1:40) hydrosulphosol drops.

NO BANDAGING REQUIRED

As many, if not the majority of, eye burns include some involvement of adjacent tissues; it may be well to note that the use of hydrosulphosol makes possible treatment of such burns without requiring bandaging of the head even in the case of face and scalp burns. This is of value both from the standpoint of morale of the patient as well as keeping the area open for inspection and treatment. The application of a 1:1 spray of hydrosulphosol solution on the face or burned areas about the face and head establishes quickly a dry, flexible coating. This coating has proven to be the only covering needed. The technic required for establishment of this protective coating is very simple. Sometimes a single application may be sufficient. Frequently additional applications may be advisable. It is important not to apply a heavier coating than is necessary to establish and maintain a dry, thin, flexible layer. But some additional applications may be advisable around the edges to prevent infection and speed healing.

Hydrosulphosol does not act as an escharotic but establishes a coating on an injured area such as a burn by depositing a thin layer of sulfur and calcium. Mellon reports²⁶ that on analysis a sample contained by weight, sulfur 8.3 per cent and calcium 5.7 per cent.

The indicated mode of action would be that the sulphydryl or sulfur in some form is absorbed by the body during the process of establishing this coating. Tests by Pierce²⁵ indicate absorption of sulfur in burn cases treated by him with topical applications only. The medication will adhere to injured tissue but it is entirely safe to apply to the intact skin as well.

A case illustrated herewith with second degree burns of the face (Fig. 2), which also involved the eyes, is typical of the eye and face burns reported in this series. It is selected because of the fact that before

hydrosulphosol therapy was applied the patient had attempted to treat the burn with home remedies for four days. When first seen by me there was swelling and indication of presence of infection. A 1:1 dilution of hydrosulphosol in distilled water was sprayed over the entire area. Hydrosulphosol ointment was applied around the corners of the mouth, nose and eyes. Before the picture in Figure 2 could be made, about four hours had elapsed after start of treatment. During that time the swelling was reduced and the patient was quickly in complete comfort. In fact she went home and resumed her normal household duties. She was seen by me daily thereafter. Additional dilute solution was applied as a spray at such points as were indicated, also ointment to areas where the spray would not adhere. Improvement was rapid and healing was complete without any scars within ten days after institution of this therapy. (Fig. 3.)

In a previous report²⁷ even faster healing of second degree burns on the face was noted. This patient was burned by live steam about the eyes, entire face, neck, chest, arms and abdomen. The application of hydrosulphosol spray 1:1 promptly relieved pain and produced complete healing of all burned areas within eight days without leaving any scars. This case was seen by me and treated within about thirty minutes after injury. This same material in ointment form was applied about the corners of the nose and mouth.

As hydrosulphosol is a chemotherapeutic agent, its maximum value as a healing agent is best realized by regular, repeated applications until all injured areas are healed.

It is important to maintain the coating as a thin pliable layer. A routine that has produced remarkable results in extensive third degree and old burns consists of the following: application of 1:1 spray to establish coating (one to four such sprays are generally ample and can be applied in thirty minutes or less with complete drying with the aid of a mild heat lamp). Then apply

four additional sprays at two-hour intervals. In the evening this coating or sufficient of it generally can be removed with a warm saline soak after which one or two applications of hydrosulphosol ointment can be made for the night treatment. In the morning remove ointment with cotton and repeat spray applications.

Repetition of this daily routine has demonstrated its value. The greatly decreased hospital time required for such patients meets effectively any objection to the slight additional medication, time and care required. The same routine is applicable also to burns of lesser severity in which even present short healing time can be reduced significantly.

PROMPT RELIEF FROM PAIN

It should be noted that although this medication does not contain any pain-allaying drug, it has the capacity to relieve pain promptly when applied to the skin and prevent recurrence of pain when used to treat burns of the eye or the skin. This capacity to relieve pain is attributable to laying down of a mechanical protection from air and a chemical union with oxygen.

When first instilled in the eye the dilute hydrosulphosol may cause a temporary stinging which wears off quickly. Even if the full strength solution should get in the eye there will be a stinging but there will not be any injury to the tissues. Reference to the use of hydrosulphosol for the treatment of eye burns is made by Kennedy³⁰ and Reeve.³¹

In the dilutions used in treating eyes the hydrosulphosol solution is prepared as follows: Drops directly in the eyes, 1:40 in warm triple distilled water at intervals of thirty minutes or up to two-hour intervals as extent of injury, progress of healing, etc., indicate.

Compresses on outside of closed lids, 1:20 in warm distilled water, applied continuously for several hours at start of treatment and then tapered off. The pH of these dilutions are as follows:

1:40 dilution _____ pH 8.2
1:20 dilution _____ pH 8.5

Because of its unique chemical composition the hydrosulphosol aqueous solution can be evaporated to constant weight to produce a concentrate which is combined with a suitable cold cream base to provide an ointment that has been used successfully, in conjunction with the solution, with satisfactory aid to healing processes in areas outside the eye where the use of an ointment would be indicated.

Another important feature of hydrosulphosol therapy observed in the series of cases reported herein was the absence of any clinical evidence of infection. This was in line with results previously reported by Pierce,²⁴ Mellon²⁶ and Cruthirds.^{27, 28}

It is well known to all who treat burns that more scarring is seen in infected burns than in non-infected ones. This is due of course to the time element. Infection prolongs healing time hence we must keep in mind one important burn treatment principle: the faster the healing, the less scarring.

CONCLUSIONS

From a review of the literature it would appear that the important rôle of sulphydryl in tissue respiration and repair is well established by scientific research. Very little reference, however, is made to the availability or use of medicants suitable for combatting dangerous deficiencies of this sulfur constituent which is present "... in all protoplasm with an active metabolism," according to Klauder and Brown.⁷

All of the work done to date on hydrosulphosol suggests a definite value for the critical proportions of its sulfur-bearing compounds, present in aqueous solution, particularly the —SH groups or sulphydryl linkages. Certainly in our work we have not encountered another agent that has brought about healing of devitalized tissue as in an x-ray burn, as has been demonstrated by hydrosulphosol.

In connection with this product two additional factors appear to have been important in connection with its use over a period of five years: (1) The comparative economy with which it can be used, and (2) the decrease in nursing and hospital care.

It is believed fair to state that, as compared to other methods, the time required to effect healing of burns can be reduced from one-third to one-half or more when employing this sulphydryl therapy. When instilled as drops in the eyes, the dilution used represents a cost of medication that can be measured in fractions of a cent. No emphasis is needed to point out the value of time that might be saved to workers and employment of a regimen that is marked with comfort for the patient and likelihood of recovery without after-scarring or contractures.

While additional study is needed to confirm various aspects related to the utilization of a product of this nature by the body in the synthesis of sulfur-containing amino acids, scientists acquainted with the chemical composition of hydrosulphosol are inclined to the opinion that it is capable of acting in this manner. Certainly clinical observations strongly suggest a mode of action that favorably influences processes concerned with tissue respiration and repair, in which functions sulfur-containing amino acids are known to play important rôles. How far this may go in favorably influencing or stimulating organs concerned with disposal of toxins and waste products, the transport of oxygen and other vital factors that may turn the tide toward recovery in serious or extensive burns, is deemed worthy of investigation and study.

SUMMARY

1. A sulphydryl therapy has been employed in treating a series of more than 500 burns involving injury to the eyes and adjacent areas over a period of five years.
2. Results observed indicate advantages over other methods expressed in (1) ability to heal x-ray burns in which tissue was devitalized or ulcerated condition and infec-

tion were present, (2) healing with less chance of development of symblepharon, (3) faster healing, (4) lack of scarring, and (5) absence of infection.

3. The product used, hydrosulphosol, presents sulfur in a "free" colloidal state with a high concentration of sulphydryl suggesting availability of sulfur in a form that can be utilized by the body in the synthesis of sulfur-containing amino acids.

4. A review of the literature reveals the importance of sulfur-containing compounds in the eye which compounds have been shown to constitute almost one-half of the mineral content of the lens, and are connected with such functions as tissue respiration, oxygen transport, detoxication, capsular permeability, protein synthesis and general metabolic efficiency. The importance of these compounds is referred to in other organs of the body—the liver, kidneys, spleen, etc.

5. In addition to its use as a treatment for burns, this product has been used in conjunction with penicillin in the treatment of multiple corneal ulcers with results not heretofore observed when using penicillin alone.

6. No contraindications have been observed for this product when used with other medicants. Also, there has been no evidence of any toxic reaction following free and repeated application and use of this sulphydryl-bearing solution.

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TOTAL EXCISION OF THE PATELLA FOR FRACTURE*

REPORT OF FOURTEEN CASES.

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INTEREST in the treatment of fractures of the patella by total excision was stimulated by the strikingly good results reported by Brooke^{1,2} in 1937. Patellectomy was not a new method of treatment; it has been occasionally practised from 1860 in treating lesions of the patella other than fractures, and it had been used in isolated cases of fractures from 1890. Despite the enthusiastic endorsement of the method following Brooke's report, particularly in England, and despite the many publications that have appeared on excision of the patella, the cases reported have actually been few in number. Indications for patellectomy in the treatment of fractures are still not well defined. The following report covers a series of fourteen cases in which patellectomy was considered to be indicated, and in eleven of which observations after an adequate lapse of time permitted evaluation of the method.

The excision method was the outgrowth of the attempt to find a more promising procedure than operative suture of the patella. The latter method, which is still the orthodox form of treatment, is followed by prolonged disability. The knee must be immobilized for from four to six weeks to ensure union. Then follows a long period of incapacity while union becomes firm and the quadriceps regains power. At best, work of a strenuous nature can seldom be resumed in less than six months.

The results of the open suture method in comminuted fractures are far from satisfactory. In a study of fifteen comminuted fractures that had been treated by suture methods in our clinic, only

two good functional results were observed. As a rule, the patella in healing becomes exceedingly hypertrophied, spreading out over the femoral condyles like a pie plate. The function is limited, and the flexion movement seldom passes beyond the right angle. In time the irregularities of the patellar surface lead to the development of arthritic changes.

Some operators claim that the results of operative suture of transverse fractures likewise are unsatisfactory, and that the method should be discarded in favor of patellectomy. Brooke^{2,3} is a staunch advocate of its use in transverse fractures. Among the objections raised to operative suture of this type of fracture is the danger of refracture because of the fibrous union that takes place. It is also claimed that complete function is never regained, and that the knee remains weak, leaving a person handicapped in climbing stairs. Moreover, if it is not possible to secure exact alignment of the fragments, there is the likelihood that the friction between the roughened patellar joint surface and the condyles will lead to the development of arthritic changes.

At the present time, surgeons are not quite ready to accept patellectomy as the routine treatment for transverse fractures, even though it is acknowledged that the method has given excellent results. A surgeon is reluctant to sacrifice the patella when the fracture is a fresh and simple break in a young or middle aged adult, because its removal presents certain possible drawbacks. Moreover, it must be admitted that the results of suture fixation of the fragments and lateral aponeurosis in transverse fractures are, on the whole,

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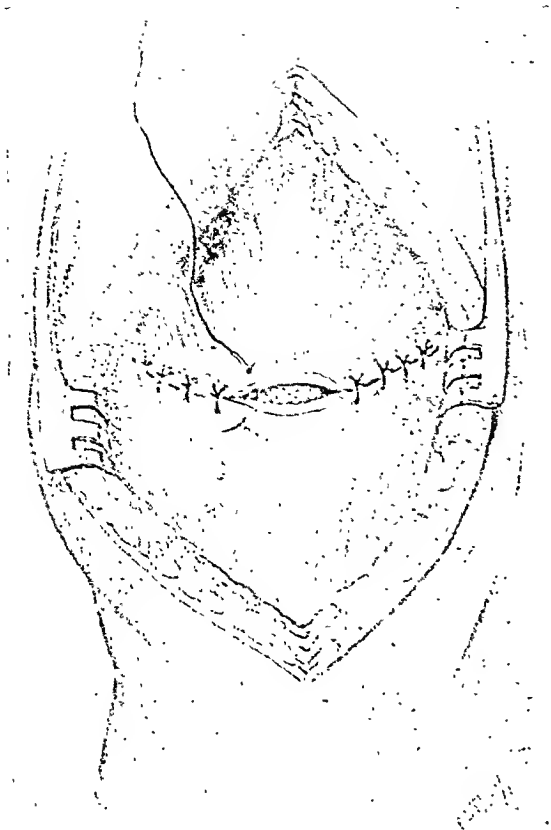


FIG. 1. Closure of the tendon and lateral aponeurosis with interrupted chromic catgut sutures.

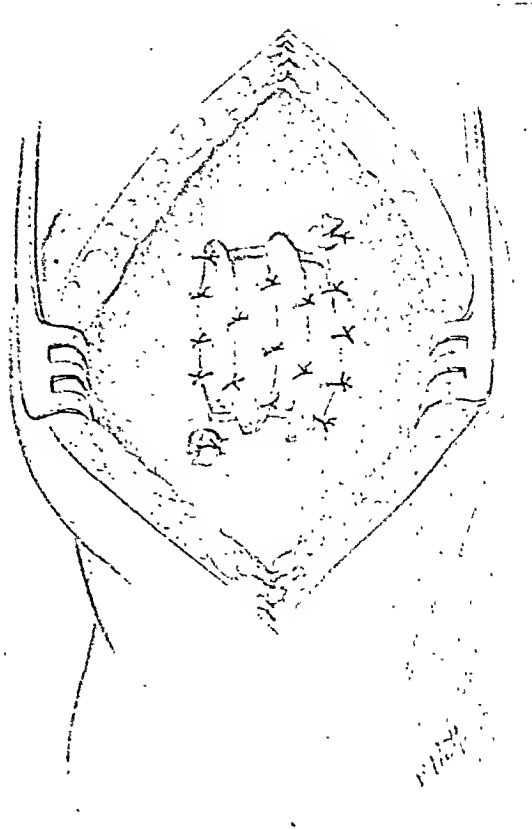


FIG. 2. Closure of a wide gap between the tendon edges by means of strips of fascia lata.

satisfactory. The prolonged convalescence, which is the great objection to the method, may be shortened materially by using screw fixation, which permits motion to be started in ten days, in contrast with the four or six weeks' delay when suture fixation is used.

Among the drawbacks to the removal of the patella is the appearance of the knee, particularly if the patient is a woman. Then, too, the patella undoubtedly protects the knee joint from direct injury in flexion positions.

The possibility of the development of arthritic changes as the result of the quadriceps passing directly over the condylar surfaces, in the absence of the patella, is another objection that may be raised. Bruce and Walmsley⁴ and Cohn,⁵ in experimental observations, noted degenerative changes in the articular cartilage of the joint following the removal of the patella. Whether similar changes

will appear in the knee of the human joint remains to be determined. Brooke³ observed no arthritic changes in a roentgenographic examination of twenty-nine cases in which the patella had been excised from five to fifteen years previously. In the series of cases herein reported, no degenerative changes were observed in a late roentgenographic examination of the knees of three patients, aged thirty-five, fifty-six and seventy years, respectively.

The question also arises as to whether the patella plays a rôle in the function of the knee by adding to the extension movement through a pulley effect, whereby the quadriceps is raised up from the condyles. There is no unanimity of opinion on the function of the patella. Brooke² believes that the patella contributes nothing to the function of the knee; rather, it is his opinion that the patella acts as a deterrent to function. Brooke's^{1,2,3} suc-



FIG. 3. A, roentgenogram taken three months after patellectomy, showing islands of ossification; B, roentgenogram of the same knee taken one year after patellectomy, showing increased density of ossified areas.

cessful results would certainly substantiate his opinion. Haxton⁶ has discussed in detail the rôle of the patella in the knee mechanism. In Haxton's experimental and anatomical study, as well as in the experimental observations of Carey, Zeit, and McGrath⁷ and Bruce and Walmsley,⁴ the patella was found to have an important functional value. Other observers in their clinical experience have noted a slight loss of the extension power and buckling of the joint following patellectomy.^{8,9,10} In the series of cases being reported, a slight laxity was noted in four cases.

Whether all of these objections to patellectomy may be obviated by regenerated areas of bone at the former site of the patella remains to be determined. The subject of regeneration is discussed further on in the paper.

At the present time when so many factors are in doubt, indications for patellectomy are, for the most part, limited to certain types of fracture. In severely comminuted fractures, whether recent or of long standing, excision offers the only

solution to the difficult problem of treatment. Excellent functional results are obtained in contrast with the uncertain results from the suture method of treatment. The convalescence is rapid, and hospitalization is usually necessary for only two weeks.

Excision of the patella is indicated in cases of malunion or non-union in transverse fractures that have been unsuccessfully treated by other methods. In such fractures, good function is recovered following patellectomy, and the development of arthritic changes from the irregular patellar surface is checked.

OPERATIVE TECHNIC

When the patient's condition permits, operative excision of the patella is carried out in forty-eight hours after the injury. (Figs. 1 and 2.) In view of the early development of atrophy of the quadriceps following a fracture of the patella, it is advisable not to delay the operation for more than five days. During the period of waiting, the knee is kept tightly bandaged



FIG. 4. A, roentgenogram taken three years after patellectomy, showing islands of bone; B, roentgenogram of the same knee taken six years after patellectomy, showing increase in bony areas.

to prevent swelling, and it is splinted in the position of extension and elevated.

A longitudinal incision, extending from the region of the lower quadriceps tendon down to about 1 inch along the patellar tendon, and just a shade lateral to the midline, is made through the skin. If preferred, a U-shaped or a transverse incision may be used. Dissection is carried out, exposing the fracture cavity, the capsular tears and the traumatized quadriceps expansions. Blood clots are cleaned out of the joint. The patellar fragments are easily shelled out from the quadriceps tendon, care being taken to keep close to the anterior and lateral surfaces of the fragments in order to avoid sacrificing any of the tendon.

The frayed edges of the extensor tendon and its medial and lateral expansions are trimmed. The freshened edges are then approximated, if possible, the quadriceps tendon being forced down to the patellar tendon. It is well to suture the aponeurosis first, as by so doing the main part of the tendon can be sutured more easily. The

ends of the tendon proper are united with interrupted chromic catgut sutures. When the ends of the tendon cannot be approximated because of contracture, strips of fascia lata taken from the thigh may be used as a running suture to close the gap.

The skin is closed with interrupted sutures of silk. A compression dressing, a snug flannel bandage and a ham splint are applied. Penicillin is given for two or three days.

Postoperative Care. Most important in the postoperative treatment is the prevention of weakness of the quadriceps muscle by early mobilization. Just when contraction exercises may begin will depend upon the extent of the damage in the soft tissues as well as upon the postoperative reaction. In the average case, contraction exercises may be started at the end of the first postoperative week, and by the tenth day the patient can carry them out well.

The splint is removed on the tenth day, and the patient begins to flex the knee gently by swinging the leg over the



FIG. 5. Roentgenogram showing large osseous flakes at the sixth postoperative month.

edge of the bed. Care is taken always to keep the motion within the limits of pain. Hot fomentations are applied for twenty minutes, three times a day. After the tenth day the patient may walk with the aid of crutches.

At the end of the second postoperative week, the patient is discharged from the hospital, and given instructions to continue exercising and using the leg. Swimming, or exercising the leg in a tub of hot water, twice a day, is recommended. Within from two to three weeks, motion to the right angle is usually established. By the third week, the patient is bearing weight and walking without the aid of crutches.

In the average case the quadriceps is strong and well controlled in from six to eight weeks. The knee functions well and is stable. The patient can walk normally and go up and down stairs. The rate of recovery depends to a great extent upon the cooperation of the patient.

Just when the patient may resume work depends upon the nature of his occupation. A person who has a sedentary position may return to work in from four to six

weeks after the operation. A laboring man is ready to resume light work in from six to eight weeks. Return to strenuous work is possible within three or four months following the operation. No heavy work should be undertaken until the tissues are well healed and until the quadriceps, which exerts excessive tension, is strong.

REGENERATION OF THE PATELLA

In experimental studies by Carey, Zeit, and McGrath⁷ and Bruce and Walmsley,⁴ calcified areas have been found to replace the excised patella. Similar foci have been noted following the removal of the patella in humans by Dobbie and Ryerson,¹¹ Albert,¹² Wass,¹³ Mehriz,¹⁴ Murphy¹⁵ and Schmier.¹⁶

Whether actual regeneration of the patella takes place in response to a mechanical need, or whether the areas of calcification develop from remaining osteoblasts is still in question. Certainly islands of density are seen in roentgenograms following excision of the patella. In a study of the late roentgenograms in eleven of the cases being reported, islands of calcification were noted in all except two cases. In one case the foci were present at the third postoperative month, and one year later showed considerable increase in density. (Fig. 3.) A similar increase in density was seen in the roentgenograms of another case that were taken during the third and sixth postoperative years. (Fig. 4.) A roentgenogram of one other case showed large osseous flakes at the sixth postoperative month. (Fig. 5.)

ANALYSIS OF CASES

The series includes fourteen cases of fractures of the patella that were treated by total excision of the bone. Nine of the patients were males. In age the patients ranged from twenty-nine to seventy-seven years. The fracture is most common at middle age.

Twelve fresh fractures were of the comminuted type, the patella being shattered throughout in six cases, broken into three pieces in two cases, the lower

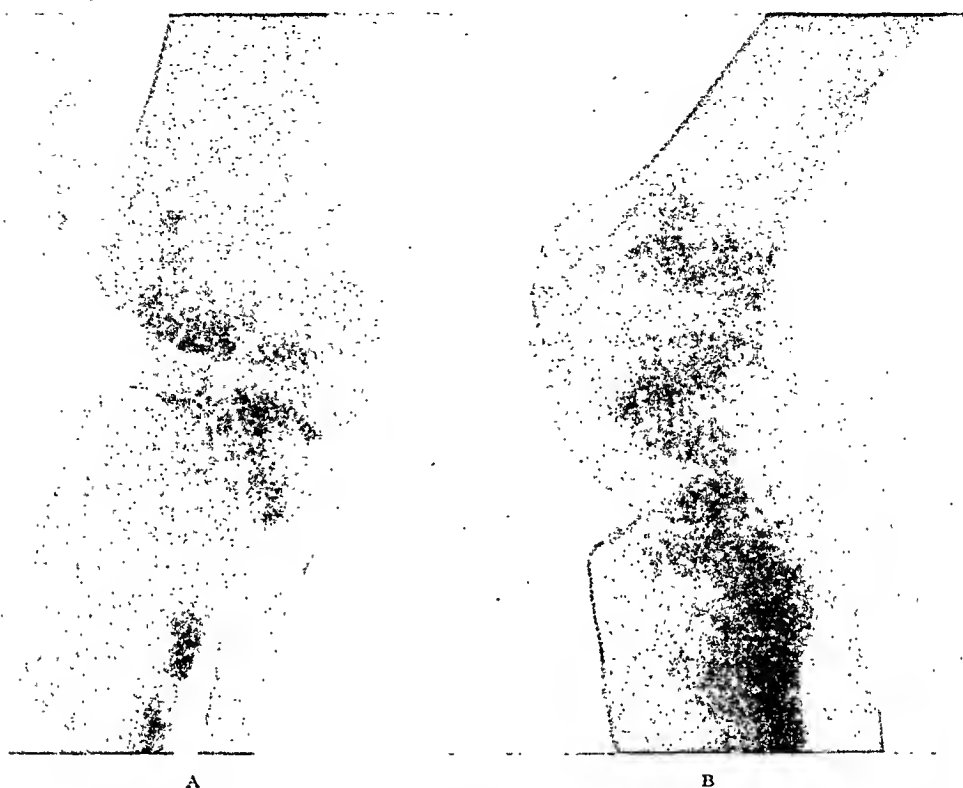


FIG. 6. A, comminuted fracture of the patella; B, roentgenogram taken two years after patellectomy.

half alone being comminuted in three cases, and the upper half in one case. One case was a comminuted fracture of long standing in which the patella was extremely broadened. The remaining case was a transverse fracture of long standing, which had been treated unsatisfactorily by other methods. One fracture only was compound.

Eight of the twelve fresh comminuted fractures were associated with other injuries. In two cases there were lacerations of the knee; in two cases, abdominal injuries; in one case, there was a Monteggia's fracture; in one case, a compound comminuted fracture of the lower third of the femur on the same side as the patellar fracture; in one case, a fracture of the elbow; and in the eighth case, the rectus femoris muscle was partly severed. The period of hospitalization in all except one of these cases was prolonged because of the concomitant injuries, and the final result in the case of the associated fracture of the femur was complicated by that injury.

Six of the twelve fresh fractures were operated upon within four days of the

injury. In the other six cases, operative interference was delayed from one week to seventeen days because of associated injuries.

The period of hospitalization in three of the twelve cases of fresh comminuted fractures and in the two cases of long standing averaged two weeks. In one uncomplicated case, the patient was kept in the hospital for twenty-four days because of his advanced age. In the remaining eight cases, the postoperative hospitalization was delayed because of associated injuries.

Results. In eleven of the fourteen cases in this series, sufficient time has elapsed to permit judging the late results. (Fig. 6.) The postoperative check in two cases was made more than six years after the removal of the patella; in four cases within two to four years; in another four cases in one year after the operation; and in one case after a period of eight months. The patellectomy in the remaining three patients was carried out too recently to permit judging the end results, but the progress made in recovery has been very rapid and favorable.

Ten of the eleven patients obtained good functional knees with perfectly free joint motion and stability. In five of the cases, every test of power and motion could be met. The patients could hold the leg out straight in full extension; they could squat fully and with ease on the operated leg; they could go up and down stairs normally; and they could walk long distances with comfort. It was impossible to detect any difference between the function and stability on the operated side and on the uninjured leg. Four of these patients had returned to their respective occupations, one as a freight handler, another as a railroad laborer, the third as a housewife, and the fourth as a chicken farmer, in from three to four months after the operation. The other patient had no occupation.

In four cases, the quadriceps was not so strong as in the normal knee, and there was a laxity of about 10 degrees that prevented complete extension. Notwithstanding, the quadriceps still had good power, the flexion movement was normal, and the patients reported no disturbance of function. The only complaint was that the knee buckled occasionally. Three of these patients did arduous work, two of them in a mill and one in a foundry.

The tenth patient, aged seventy-seven years, had complete motion of the knee in both extension and flexion when she was examined in one year. However, she had to go down stairs a step at a time.

In the eleventh case, the outcome was poor. Flexion of the knee was possible to only the right angle. There was a tender area over the bridge between the patellar and quadriceps tendons, indicative of weakness.

SUMMARY

A report has been presented on the treatment of fourteen fractures of the patella by total excision of the bone. In eleven of the cases, sufficient time had elapsed to judge the end results. Ten of these patients obtained good functional knees. The convalescence was rapid, and

the patients had returned to work in much shorter time than is possible under suture fixation methods.

The procedure is considered to be indicated only in certain fractures. It offers a solution of treatment in severely comminuted fractures, whether recent or of long standing, in which under the orthodox suture methods, the period of disability is prolonged and the results are unsatisfactory. Patellectomy is also indicated in transverse fractures of long standing in which malunion or non-union has resulted. The method is not recognized as the established treatment of fresh transverse fractures.

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ANORECTAL ABSCESES*

DISCUSSION AND TREATMENT

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THE purport of this discussion is three-fold: (1) the localization of abscesses in the anorectal spaces; (2) the spread of infection along the fascial planes of the perineum to definite areas, namely, the perinephrium, pelvic cavity, thigh, scrotum or labia, along the spermatic cord and the abdominal wall, and (3) the surgical approach necessary to stop the spread of infection and to prevent fistula formation.

The anorectal spaces are classified according to their location above or below the levator ani muscles:² *I. Supralelevator spaces:* (1) pelvirectal; under the peritoneum between the lateral wall of the rectum and superior surface of the levator ani muscle; (2) retrorectal; under the peritoneum, between the rectum and sacrum, bounded laterally by the lateral ligaments of the rectum; (3) intramural (submucous); under the mucosa of the rectal wall. *II. Infralelevator spaces:* (1) marginal, between the external sphincter and the lining of the anal canal; (2) perianal, between the external sphincter and skin; separated from the ischiorectal space by the tela subcutanea; (3) ischiorectal, bilateral, beneath the levator ani muscle. This space is potentially connected with the space on the opposite side both anterior and posterior to the anus. The levator ani with its enveloping fascia forms the main portion of the pelvic diaphragm and blends anteriorly with the urogenital diaphragm giving an anterior projection to the space. Colles fascia coming from the scrotum and uniting

with the posterior edge of the urogenital diaphragm separates the ischiorectal space on each side from the corresponding superficial perineal space which is an approach to the suprapubic area. The obturator internus muscle at the lateral border of the ischiorectal space guards the obturator foramen leading to the thigh. The tela subcutanea separates the ischiorectal space from the perineal space and from the skin. Laterally the tela subcutanea blends with the gluteus maximus muscle and medially with the external sphincter.¹⁶ Figure 1 illustrates the anorectal spaces.

Anorectal infections begin at one of four sites: (1) Anorectal lining; (2) the perianal skin; (3) deep glands connected with the urogenital tract;^{1,15} and (4) coccyx and sacrum.⁶

Anorectal Abscesses Beginning at the Lining of the Anus and Rectum. This approach accounts for a predominant number of anorectal abscesses. The mucosa of the rectum covers the hemorrhoidal venous plexuses to the crypts of Morgagni where it changes to a more resistant type of stratified squamous epithelium and at the anocutaneous junction it becomes skin.

Like any mechanism, wear and tear is greatest where the friction of moving parts is greatest. The sphincters, contracted while at rest, act as a shelf for the stool above and expose the mucosa to contact injury by solid particles. Pathological structures act similarly. The voluntary shearing action of the external

* From the Department of Proctology, Detroit Receiving Hospital; a study of seventy-seven cases with the assistance of Howard Keiser, M.D., resident.

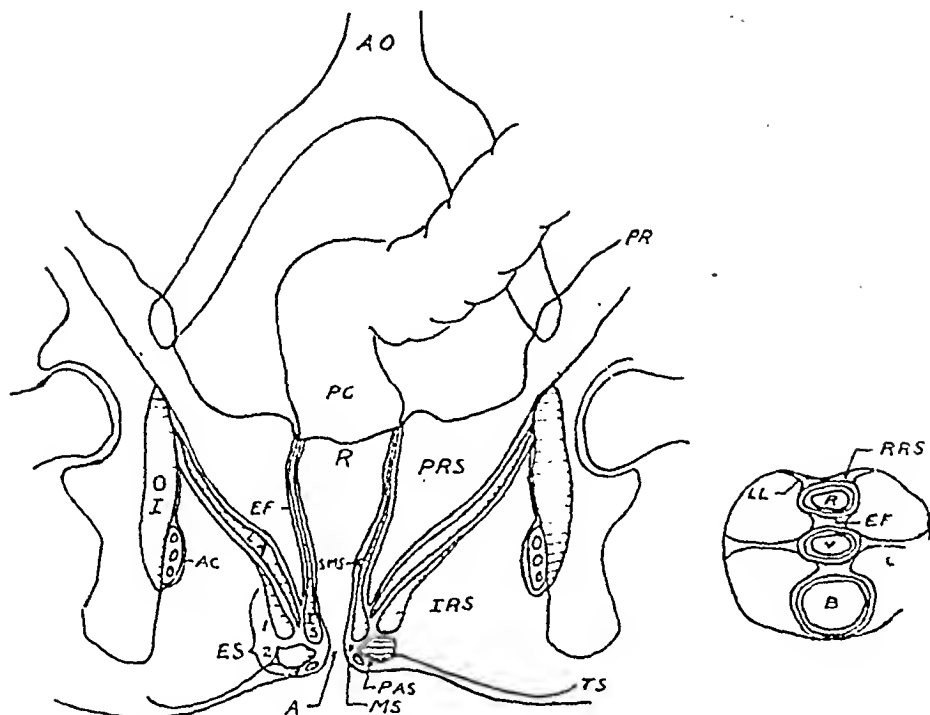


FIG. 1. PRS, pelvifectal space; RRS, recto-rectal space; SMS, submucous space; IRS, ischio-rectal space; PAS, perianal space; MS, marginal space; EF, endopelvic fascia; PC, pelvic colon; AO, aorta; TS, tela subcutanea; PR, peritoneal reflection; R, rectum; V, vagina; B, bladder; A, anal canal; LL, lateral ligament; C, cardinal ligament; IS, internal sphincter m.; ES, external sphincter m.; 1, deep; 2, superficial; 3, subcutaneous; LA, levator ani m.; AC, alcock's canal; OI, obturator internus m.

sphincter exposes the epithelium of the anus to direct abrasion. The pull of the levator between the sphincters adds to the danger of a break in the lining. The crypts of Morgagni are at the same level and often become pockets of infection which erode through the lining. Foreign bodies lodge in the crypts and perforate the lining. Prolapsed internal hemorrhoids may become thrombotic and form an ideal medium for bacterial growth.¹

Foreign body perforation, cryptitis, fissure, ulcer, stricture and thrombotic or eroded hemorrhoids are the common points of origin of anorectal abscesses which begin within the anorectum.

Once infection breaks through, a cellulitis ensues. The inflammatory reaction often seals the point of entrance. The infection spreads outward. Pus forms and follows the path of least resistance. The spread of infection through the wall of the rectum is prevented by the serosa and the enveloping endopelvic fascia; but at

the anus these structures are absent giving pus direct access to the anorectal spaces. If the spread is upward under the mucosa, a submucous or intramural abscess of the rectum will form; if the pus breaks through between the internal sphincter and levator ani (pelvic diaphragm), a pelvirectal abscess will result; if this occurs in the posterior midline between the lateral stalks of the rectum, a retro-rectal abscess follows.² When the spread of pus is downward under the anal lining, marginal and perianal abscesses result. If pus breaks through between the levator ani and the external sphincter, an ischio-rectal abscess forms. Once the ischio-rectal space is invaded extension may connect any other infralevator space. Pus erosion from an ischio-rectal space through or around the medial edge of the levator may extend to any supralevator space. Pus in one ischio-rectal space may extend through to the opposite space either in front of or behind the anus, forming an

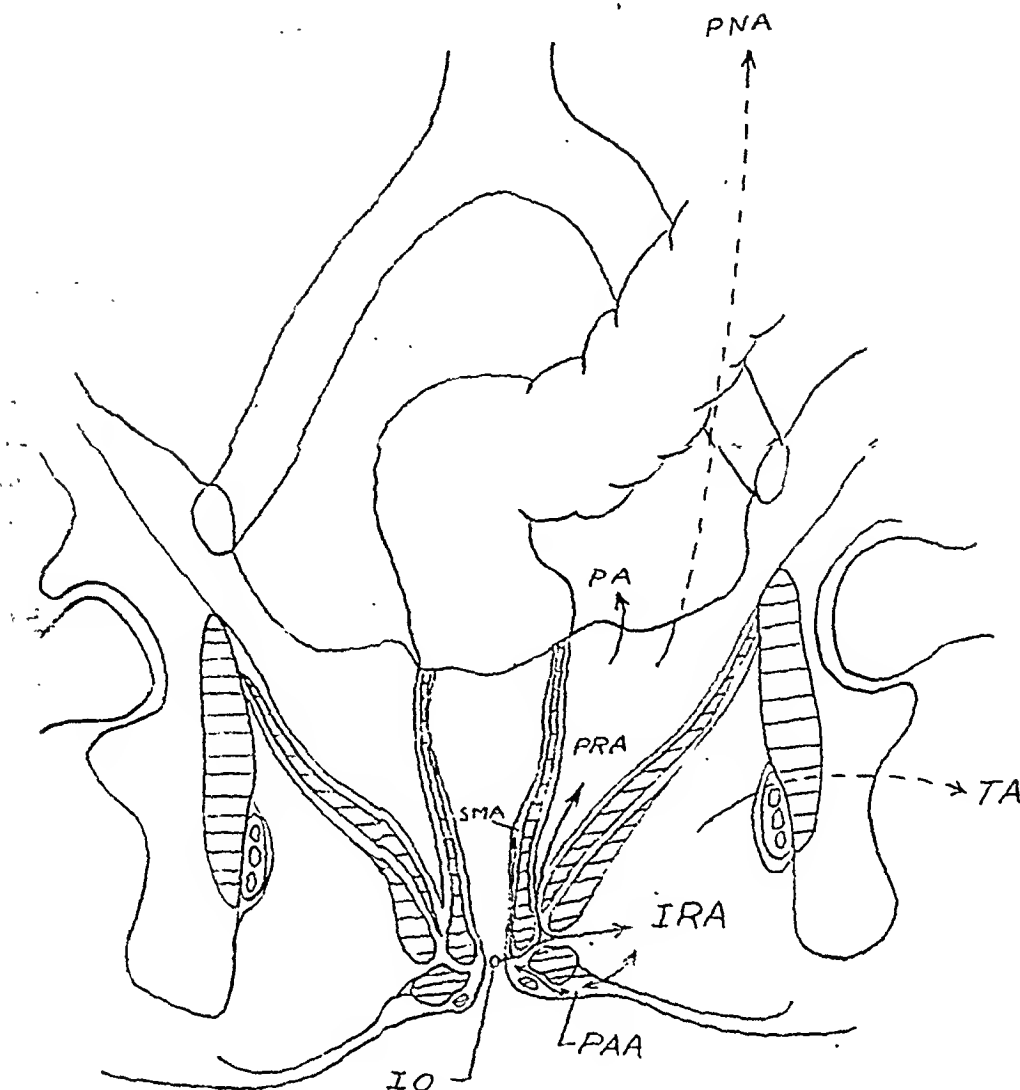


FIG. 2. PAA, perianal abscess; IRA, ischioanal abscess; SMA, submucous abscess; PRA, perirectal abscess; PNA, perinephritic abscess; PA, pelvic abscess; TA, thigh abscess; IO, internal opening.

H-shaped or a "horseshoe" abscess. Figure 2 illustrates these pathways.

Anorectal Abscesses Beginning at the Skin. A break in the skin or an infected skin gland (sebaceous, sweat or apocrine) are the points of origin. Once through the skin, infection has direct access to the perianal space. Perianally, the tela subcutanea is interlaced with fine muscle fibers from the external sphincter, but under the skin of the buttock the tela is interlaced with fatty tissue¹⁶ which offers but little resistance to invasion of the ischioanal space. Spread from a perianal space can involve any other space and erosion may cause extension in the anorectum to form an internal opening.

Anorectal Abscesses Beginning in the

*Deep Glands Connected with the Urogenital Tract.*⁵ (Fig. 3). Common offenders are the prostate, seminal vesicles, Cowper's and Bartholin glands. Prostatic abscesses commonly rupture into the urethra, but rupture may occur directly through the rectal wall and but rarely into the perineum and the supralelevator spaces. Seminal vesicle abscesses may rupture directly into a supralelevator space. Cowper's gland abscesses, situated beneath the main portion of the urogenital diaphragm, have direct access to the related ischioanal space. Active involvement of a Bartholin gland associated with anorectal abscess has been observed.

*Inflammation of the Sacrum and Coccyx (Osteitis and Periostitis).*⁶ (1) *Pyogenic:*

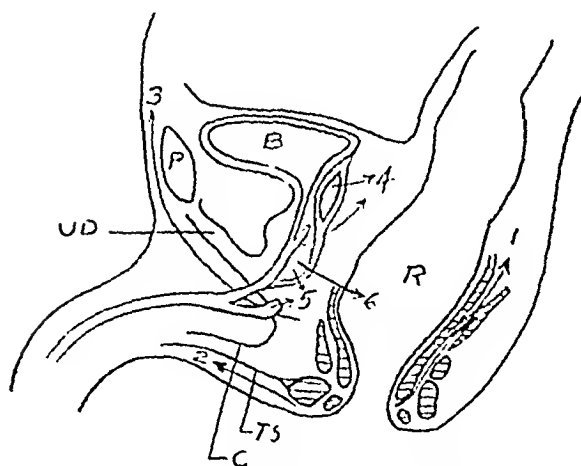


FIG. 3. B, bladder; UD, urogenital diaphragm; r, pubes; 1, to retrorectal space; 2, perianal space to scrotum or labia; 3, through Colle's fascia and superficial perineal space to suprapubic space; 4, prostate and seminal vesicle to supralevator space; 5, prostate and Cowper's gland to ischiorectal space; 6, prostate into rectum; C, Colle's fascia; TS, tela subcutanea; R, rectum.

Suppurative periostitis may begin as a simple or as a purulent inflammation. The pus is formed in the inner layers of the periosteum or between it and the bone. The outer layers of the periosteum may resist the suppurative process for a long time. The accumulation of pus may dissect the membrane from the bone and leave the latter bare. The pus thus formed may remain in this position for a long time, be absorbed or become dry and cheesy; it may burst through the periosteum and lead to abscesses in the soft parts. The bone, if separated from its nutrient membrane, often becomes necrotic and may be absorbed. (2) *Syphilitic*: Syphilitic infection may excite a purulent periostitis. The bone tissue is usually more or less involved. The gummas may be absorbed or may suppurate. (3) *Tuberculous*: Chronic purulent periostitis is frequently associated with the formation of miliary tubercles. Abscesses are apt to form in and about the periosteum and when these are evacuated, granulation tissue containing tubercles may develop.⁶

Pus may spread from the anorectal spaces to the pelvis, perinephritic area, suprapubic area, thigh, scrotum or labia:

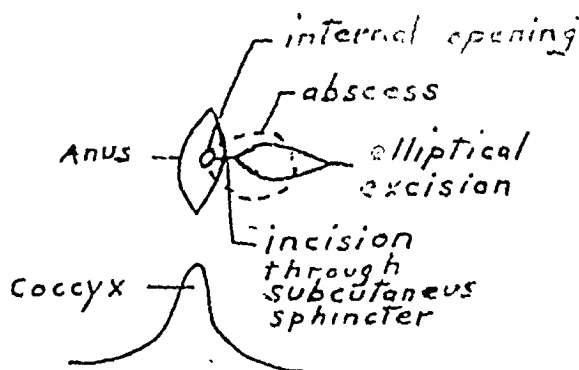


FIG. 4. Perianal abscess with internal opening; elliptical excision of skin forms external opening; wound treated as fistula; incision through sphincter joining external and internal openings.

(1) Pelvic abscess may follow the erosion of pus in a pelvirectal space through the peritoneum into the pelvic cavity. (2) Perinephric abscess may follow the peritoneal spread of pus from an abscess to the kidney region.⁵ (3) Suprapubic abscess not infrequently follows extension from an ischiorectal abscess. The ischiorectal space is separated from the superficial perineal space (under the urogenital diaphragm) by the reflection of Colles fascia from the scrotum to the posterior edge of the urogenital diaphragm. This prevents extravasated urine from flowing backward into the ischiorectal space and pus from the ischiorectal space from entering the anterior perineum. However, when pus erodes through Colle's fascia from an ischiorectal space into a superficial perineal space, the further spread of pus will be the same as that of extravasated urine, which is along the spermatic cord to the suprapubic area.¹⁰ (4) Scrotal or labial involvement may result from a perianal abscess by the spread of pus along the tela subcutanea to the dartos muscle of the scrotum in the male or to the labia majora in the female. (5) Abscess of the thigh may follow the rare erosion of an ischiorectal abscess through the obturator foramen.¹⁰

A case in point at another hospital was brought to our attention following autopsy:

Case No. 78502 S.M.H. The patient was semi-comatose; the history was obtained from

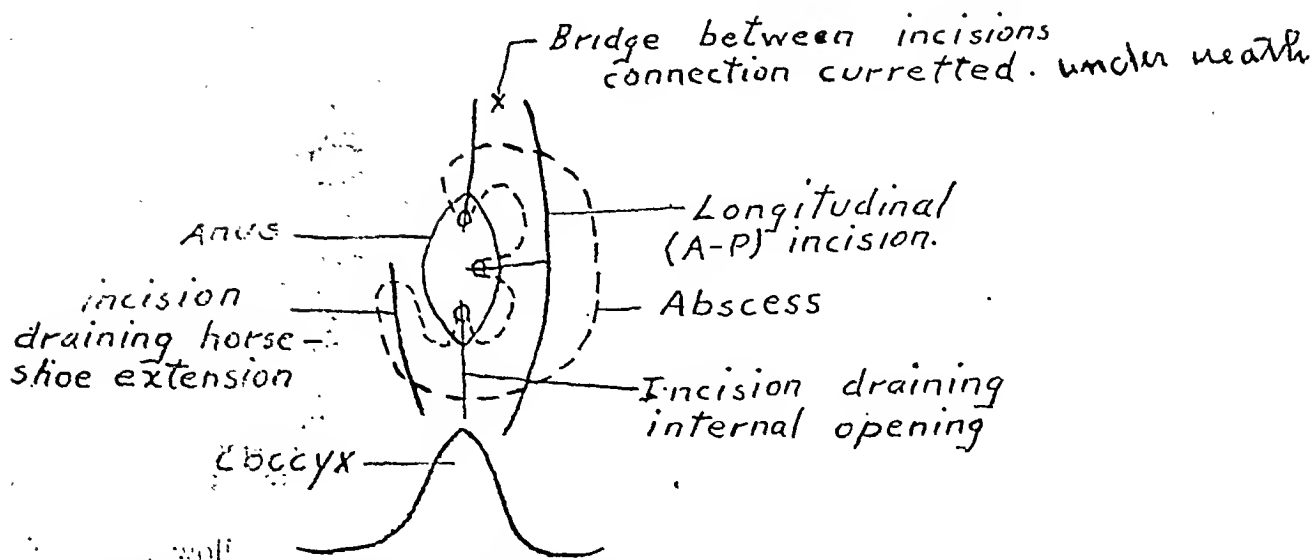


FIG. 5. Ischiorectal abscess showing internal openings at three diagrammatic positions; anteroposterior incisions drain abscess cavity and create external openings of fistula; second incision extends from internal opening laterally, traversing sphincter fibers at right angle; with good drainage, healing occurs from the inside starting internal opening.

physician. The chief complaints were vomiting and inability to urinate.

A perianal fistulectomy had been performed in an office on May 9, 1945. A moderate amount of seropurulent exudate was found in the tracts. After three days of apparent uneventful recovery the patient was unable to urinate and 3 to 4 ounces of urine were obtained by catheter. During the following twenty-four hours, 150 gr. of aspirin were taken for pain. On the fifth postoperative day the patient felt something "give" while straining at stool. He became weak, nauseated and fainted. Shock with persistent vomiting followed and the patient was admitted to the hospital on May 14, 1945. His past history was irrelevant except for the fistula which had been present for ten years.

Physical examination revealed the temperature to be 103.6(R); respirations 28; pulse unobtainable. The skin was moist and cold. Heart and lungs were normal. The abdomen revealed tenderness in the right upper quadrant and flank; there was no mass or rigidity. The back and anorectum were not examined. The patient was restless, irrational, cyanotic, vomited coffee-ground material and expired four hours after admission.

Autopsy showed that in the perianum there were two rather fresh surgical wounds 3 by 6 cm. and 4 by 8 cm. In the abdomen, green yellow pus was found on either side of the rectus sheath to a level 2 cm. below the umbilicus; 50 cc. of purulent fluid was obtained

from the right lower quadrant and the adjacent loops of bowel were covered with flecks of yellowish pus. Pus was noted in the soft tissue surrounding the right spermatic cord and the right scrotal sac. Purulent material was noted surrounding both psoas muscles, aorta and right kidney. On the left side of the hip there was a white, indurated, fluctuant area 20 cm. in diameter. Palpation revealed crepitation involving the right side of the trunk, flank, and inguinal region; it extended downward on the anteromedial aspect of the right thigh to the knee.

The clinical picture was suggestive of abdominal pathology; urinary suppression; missed diagnosis due to lack of digital examination; the spread of infection along the anorectal fascial planes to the inguinal area, scrotum, abdominal wall, pelvic cavity, retroperitoneum, perinephrium and thigh.

A review of seventy-seven successive cases of abscess of the anorectal region from the Proctology Service of Dr. E. G. Martin at Receiving Hospital in Detroit over a period of two years revealed the following:

1. Sex: Males 41, Females 36

2. Age groups:

Age:	0-10	10-20	20-30	30-40
Cases:	2	4	25	24
Age:	40-50	50-60	60-70	
Cases:	13	7	2	

3. Type:

Perianal	28
Ischiorectal	36
Supralevator	13

4. Internal opening:

Present in	28
Not found in	49

In eight cases the internal opening was due to a pre-existent fistula. Two internal openings were found in one case.

5. Seton: used in four cases

6. Operative Complications:

(a) A chicken bone was found in two cases of ischiorectal abscess; thorough search did not reveal the internal opening (point of origin of infection) through which the bone left the anorectum.

(b) Three patients with supralevator abscesses were admitted near extremis requiring transfusions and supportive therapy previous to surgery. Two recovered; one expired on the third day in spite of two attempts to secure drainage.

(c) In two cases of perianal abscess, repeat surgery was necessary five days later for supralevator abscess.

(d) In two cases of ischiorectal abscess, direct extension was found in the superficial perineal space, in the scrotum, along the spermatic cord and in the suprapubic space; in a severe diabetic, extension continued up the abdominal wall to the lower rib margin but the patient recovered.

(e) The coccyx was removed in one case.

7. Results: (Clinic records were available in forty-five cases).

(a) Fistula: 3

(b) Inactive indurated area: 1

(c) Cellulitis: 1; subsided without repeat surgery

(d) Stricture: 2; one ascribed to lymphopathia

(e) Incontinence: temporary in 1; partial in 1

The diagnostic criteria of anorectal abscesses include fever, leucocytosis, toxemia and local manifestation. The marginal perianal and ischiorectal varieties are self-evident because of pain, swelling, induration and redness. The supralevator group offer a more complex picture; pain is absent until downward spread has reached the sensory nerves of the anus; the chief complaint is rectal discomfort or fullness; toxemia is apparent; meningismus may appear; peritonitis produces abdominal pain and ileus; fever is high; diarrhea is common due to a localized procoto-colitis; palpation of the buttock on the affected side offers resistance due to levator spasm with but little tenderness; the skin is warm; digital examination reveals internal heat, induration of the rectal wall or bulging and fluctuation.

Treatment is adequate surgical drainage predicated on a knowledge of the anorectal spaces and their connecting pathways. The process of erosion must be reversed to one of granulation. An abscess cavity will granulate and heal in an inverse ratio to the size of the drainage incision.¹³ Débridement shortens morbidity; necrotic tissue should be excised and not left to slough; pockets must be obliterated. Remaining devitalized tissue is manifested by a continued toxemia from its absorption. Surgical exposure must be sufficient to reveal an extension to another space.

Previous to the drainage of any anorectal abscess, adequate dilatation and thorough search of the anorectum should be done to reveal any existent internal opening. Crypts, ulcers and fissures are common sites of an internal opening. A sealed internal opening will usually become patent by adequate dilatation with a bi-valve speculum (spinal anesthesia prevents disruption of sphincter fibers) aiding pus to appear at the internal opening.¹⁸ Any irregularity in the anorectal lining should be investigated with a crypt hook. Often light scarifying of a suspicious area will be rewarded by the appearance of pus. If an internal opening is overlooked, the

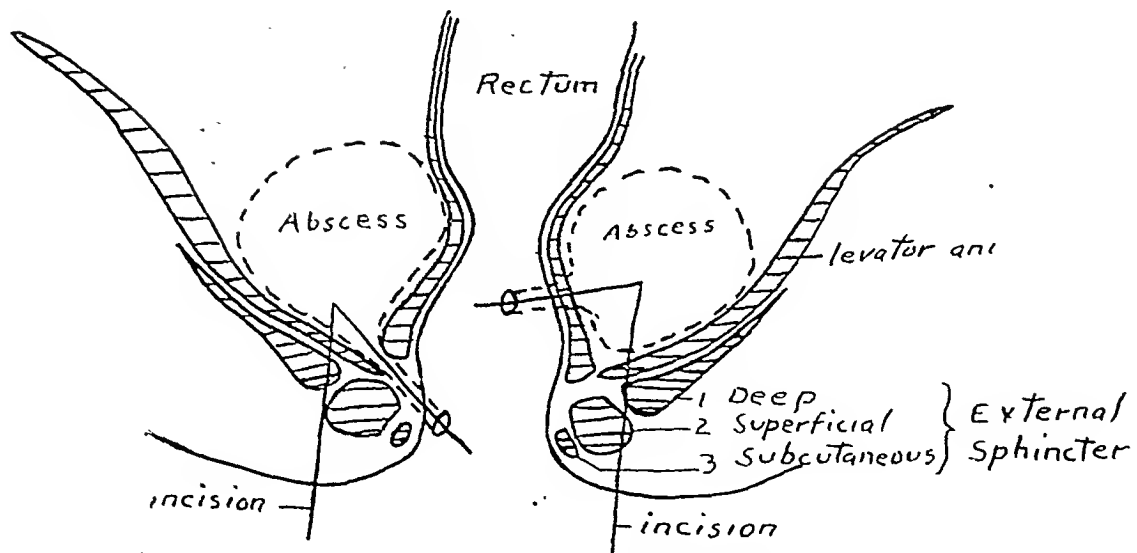


FIG. 6. Suplevator abscess. Anteroposterior incision through skin posterolateral to superficial external sphincter extended upward into abscess cavity by puncturing levator ani muscle completes fistula formation; superior half of all muscle fibers inside the loop of the fistula are divided at the first stage; seton placed around the external muscle fibers and skin. With low internal opening the operation may often be completed at one stage.

skin incision forms the external opening of a fistula which may heal with the drainage of pus but is prone to redevelop some months later.⁴ An internal opening must be extended to the outside unless a fistulectomy is planned at a later date. An internal opening may be the point of origin of an abscess, or it may be the site of erosion. As a general rule, the external skin incision is made in the same manner, whether an internal opening is present or not.

Perianal abscesses respond well to radial drainage. Drainage of this type should be by elliptical excision of skin rather than incision. The radial incision is closed by postoperative contraction of the sphincter, whereas radial elliptical excision, completely unroofing the abscess, maintains adequate drainage. Plastic effect and the avoidance of nerve injury are the advantages of radial drainage when contrasted to a longitudinal incision lateral to the sphincter fibers.

In 1922, D. C. McKenney advocated the treatment of small abscesses as fistulas.¹⁴ An internal opening associated with a perianal abscess requires but little added surgery. The abscess usually occurs opposite the internal opening. If the abscess has not ruptured, anal dilatation will

cause pus to escape at the site of the internal opening. An elliptical excision of skin in a radial direction unroofs the cavity; the connection between the cavity and internal opening is confirmed by probe or peroxide injection. If incontinence does not threaten (the internal opening is rarely deep in a perianal abscess), the interposing sphincter fibers are incised at a right angle and the "mucosa" about the internal opening excised, as in Figure 4.

Ischiorectal abscesses respond best to a longitudinal anteroposterior incision (along the long axis of the ischiorectal space) throughout the length of the abscess. When the anus contracts postoperatively it retracts the medial edge of the incision, pulls the wound edges apart and thus maintains drainage. If the entire width of the ischiorectal space is involved, a lateral extension forming a "T" will prevent an overhanging lip under which purulent material may collect. The pudendal nerve, which crosses the space from Alcock's canal to a superficial position at the anus, should be protected to avoid a flaccid sphincter.

Counter drainage and button hole drainage are to be deprecated. They invite recurrence because they allow a roof to

persist over an infected tract; they do not lend themselves to adequate investigation for extension to other spaces; they allow erosion of tissue to continue; they lead to an increased incidence of secondary fistulectomy.

Treatment of an ischiorectal abscess complicated by an internal opening requires both an external skin incision and one extending from the internal opening at a right angle through an involved sphincter. Thus two separate incisions are made; any intervening skin is thoroughly curetted following débridement. (Fig. 5.) Anal dilatation will usually reveal pus at the internal opening even though it may have become sealed. A probe is helpful in determining a connection. The injection of peroxide of hydrogen into an opening with slight pressure may disclose a patent opening at the opposite end of a tract.

An ischiorectal abscess may erode through Colles fascia deep to the transverse perinei musculature into the superficial perineal space of the corresponding side and may then follow the fascial reflections to the scrotum or labia and along the spermatic cord to the suprapubic space of the abdominal wall. Such extension requires multiple incisions of the involved areas. The transverse perinei muscles are not divided. Properly drained, the wounds heal from within, at times leaving a short, completely external fistula under the skin bridge which can be opened later with local infiltration. When too great a portion of the sphincter fibers are involved in an anterior area, the internal or deep fibers are divided and a seton placed around the superficial fibers and intervening skin. Later, when the divided muscle has reunited, the superficial sphincter fibers and skin, encircled by the seton, are divided. The wound edges are separated daily thus permitting the wound to granulate and heal. (Fig. 5.)

Pelviorectal and retrorectal abscesses should be drained from without. A long incision is placed lateral to the anococcy-

geal ligament and external sphincter fibers; the levator ani muscle is punctured bluntly and the opening widened.

The surgical treatment of pelviorectal supralelevator abscesses associated with internal opening requires staunch courage and adherence to principle. Jackman, in his recent article on fistulas, states, "Another reason for anal incontinence is permitting the inflammatory process to continue without treatment. In so doing, much more scar is formed and muscle tissue itself is destroyed by the pathologic process. . . . If the fistula is to be cured, all the tissue overlying the fistulous tract must be incised whether or not muscle intervenes."¹¹ To drain the abscess externally and leave the internal opening invites recurrence and deep fistula formation. With incision and drainage established through the skin and levator muscle, a fistula has been created. Surgical correction for the fistula can then be instituted immediately. There is no need to postpone this phase of the operation until infection has subsided and a tract has formed. With immediate incision of the encircled tissue more adequate drainage is accomplished resulting in less tissue destruction and fibrosis. An incision made in the levator tends to close quickly and form a bottleneck requiring secondary incision; this danger does not exist if immediate incision of the encircled tissue is instituted. If the internal opening is high and the tract is superior to a major portion of the sphincter, a two-stage incision with seton may be used. (Fig. 6.)

Judgment as to the immediate incision of the encircled sphincter fibers or the two-stage division with seton is dependent upon three factors: (1) Evaluation by palpation of the percentage of sphincter fibers lying superficial to a probe placed in the tract as compared to the amount of sphincter lying deep to the probe;¹³ (2) division of sphincter fibers at a right angle; and (3) radical incision permitted in the posterior midline with increased

conservatism and use of the seton as the anterior midline is approached.¹³

The use of rubber drains implies inadequate surgical drainage. They have their indication in establishing a sinus through the levator but do not replace passing a gloved finger throughout the tract every one or two days.¹⁹ Gauze packs help to control bleeding the first twenty-four hours; beyond that time they counteract drainage.

An adequately drained abscess heals promptly. Inadequate drainage manifests itself after four days by persistent pain and tenderness, indurated wound edges, purulent discharge, fever and toxemia. If these findings are present, drainage has been inadequate for one of the following reasons: (1) overhanging flap, (2) agglutination of the sides of the incision (insufficient separation with gloved finger), (3) persistent necrotic tissue in the cavity (incomplete débridement), (4) extension of infection to another space, (5) unsuspected internal opening, (6) persistent focus of infection, as an infected coccyx or urogenital gland, and (7) systemic disease such as tuberculosis, syphilis, diabetes or *Bacillus Welchii* infection.

SUMMARY

Infection gains entrance to the anorectal spaces from the anorectal lining, the skin, the glands of the urogenital tract or an infected coccyx and sacrum. Pus localized in the anorectal spaces to form abscesses, spreads along fascial planes to definite areas, namely, the perinephreum, pelvic cavity, thigh, scrotum or labia, along the spermatic cord and the abdominal wall. Treatment is radical drainage to the outside. Emphasis is placed on the search for an internal opening previous

to surgical drainage. As a general rule, the external skin incision is made in the same manner whether an internal opening is present or not. If an internal opening can be demonstrated, external drainage alone will be followed by fistula. To avoid fistula formation, internal openings are included in the surgical correction of the abscess, following the same rules as apply to fistula. Surgical drainage should be so radical that reliance need not be placed on rubber drains or gauze packs.

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DISTAL ECTOPIC PREGNANCY*

IMPLANTATION OF THE OVUM IN THE CERVICAL MUCOSA

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UNDER normal conditions the corpus uteri, vested with a mucosa especially suitable for the requirements of pregnancy, provides the exclusive ground for placentation; the isthmus which is incorporated at an early time into the cavity harboring the fetal sac, serves only for the attachment of the membranes; the cervix has nothing to do either with the membranes or the ovum. In pregnancy it serves to occlude the uterine cavity towards the outside; during parturition it forms a part of the birth canal.

Under exceptional and rare circumstances, however, the fertilized ovum may embed itself in the mucosa of the isthmus or of the cervix. Although the nidation in the isthmus is, no doubt, a pathologic one, it is not to be regarded as ectopic; since by its very nature the isthmic mucosa represents a corporeal mucosa, differing from the actual endometrium corporis by its lesser development and a certain functional weakness. The cervical mucosa, on the other hand, differs basically from the mucous membrane of the corpus and isthmus. It does not pass through phasic changes and is in no way equipped to nourish the ovum or to fulfill the other requirements which the growing fetus demands of the maternal tissue. For this reason this type of pregnancy is a true ectopic pregnancy and as against the ectopic pregnancy proximal to the uterine body, to be termed distal ectopic pregnancy. This designation is furthermore justified by the fact that the pathological changes associated with this ectopic gestation are fundamentally the same as those of a tubal pregnancy, consisting in destruction of its nutrient medium and an almost

regularly premature termination by internal or external rupture of the gestation sac. The structure as well as the topographical position of the cervix, however, bring about differences which are conspicuous especially on viewing the clinical picture.

Theoretically, the possibility of implantation of the ovum in the cervix was acknowledged for a long time; but its actual occurrence was considered improbable and not proved. Ahlfeld and Aschoff were of the opinion that although the occurrence of a cervical pregnancy must be accepted as possible, still, up to 1904, no proof had been given to show that the ovum could have been implanted in the cervical mucosa after having passed the internal os. Likewise Pankow stated in 1927 that a true cervical placenta, implying that the ovum was exclusively and completely lodged in the cervix, and that the primary implantation took place there, too, has so far never been observed with certainty. In Davis' *Gynecology* of 1934 we find the following statement: "Cervical pregnancy is an almost unbelievable phenomenon, but, nevertheless, a few cases have been reported."

It was the publication of a case of a two months old pregnancy in the portio vaginalis cervicis uteri in 1926 which enabled me for the first time to establish evidence that an implantation of the ovum in the cervix actually does occur. On reviewing the literature existing at that time about sixty cases of pathologically distal pregnancies were found. We were surprised that in none of these cases had an exact proof of exclusive cervical placentation been offered. Shortly before this, Mueller arrived at the same conclusion in a critical review of literature. In 1942, a case of cervical

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pregnancy, published below, came to my knowledge, which induced me to look into and check the entire pertinent literature since 1926, to see how far evidence of a primary cervical implantation could be accepted from the existing descriptions. From a total of thirty cases published as cervical pregnancies, I believe that I am able to show that there are ten cases of provable cervical implantation. These cases together with the one published here and the one observed by me previously—altogether twelve—form the basis for the present observations on cervical implantation of the ovum.

CASE REPORT

This was a patient of Dr. Kurt Fraehtmann, of New York, who has kindly permitted me to present the case.

On February 12, 1942, he was called to a patient because of severe vaginal bleeding. The patient was a forty-year old woman who, to date, had been essentially healthy, and, above all, had never had any gynecological disturbance. Once, seventeen years previously, she had had a normal delivery. During the last year she had had sexual intercourse without contraceptive precautions. Menstruation had always been regular, every four weeks and of four days' duration. The last normal menstruation had occurred on December 20, 1941, had been of normal duration and of normal amount. In spite of the cessation of menstruation in January, the patient felt well. The skipping of menses was mistaken by the patient for a sign of menopause.

On February 12, 1942, about seven weeks after the last menstruation a vaginal hemorrhage started suddenly, about noon, not preceded by cramps and not associated with any other symptoms. The flow was from the start heavier than a menstrual period. The patient, therefore, went to bed and called the doctor. When the family physician saw her two hours after the hemorrhage had started, the under-sheet was already soaked with blood. In view of the violent bleeding, and of the fact that a period had been missed, the doctor assumed an ordinary abortion and called the gynecologist without having examined the patient vaginally.

The gynecologist saw the patient three hours after the onset of the hemorrhage. She was a delicate, fairly well nourished woman, resting quietly in bed, apparently in shock from hemorrhage. The skin was pale and cool to touch. The forehead was covered with perspiration. The pulse was 130 and thready. There was a puddle of blood between the thighs.

On vaginal examination the vagina was distended with blood clots. The cervical orifice was open two fingers, and the cervical rim was thin. One gained the impression of a crater within the cervix, reaching upwards 2 to 3 cm. The wall of the crater felt firm and in some places even hard. At one spot (between 6 and 9 o'clock) a tumor-like growth was palpable, firmly attached to the cervical wall, and friable on its surface. A vigorous manual exploration of the crater was avoided in order not to irritate the apparent source of the bleeding any more.

The patient was immediately transferred to the hospital, and orders were given by telephone to have the operating room ready for a vaginal packing. A preliminary diagnosis of endocervical, disintegrating, profusely bleeding tumor was made.

After arrival of the patient at the hospital, the bleeding became less profuse. On bimanual examination an enlarged and anteflexed uterine body could be felt. The consistency was normal, rather hard. The adnexa and parametria were normal.

On inspection, the vagina disclosed a moderate amount of liquid blood along its walls. The uterine orifice was dilated 2 or 3 cm., and its margin was thin and smooth. The cervical walls were grasped with three vulsella and pulled downward and apart. The inside of the cervix became clearly visible. The cervix was filled for the most part with a disintegrated, tumor-like, blood imbibed mass, about the size of a walnut. The base of the tumor reached downward close to the uterine orifice, from which it was separated only by a 1 to 2 mm. wide, pale mucosal area. To the left and above the tumor one could reach with a probe into the upper part of the cervical canal, passable by a Hegar probe No. 5. The distance between the external cervical orifice and the beginning of the canal above the tumor was 4 cm. and between the external orifice and the fundus uteri, 8 cm. The base of the tumor was grasped by two clamps and the tumor was forcibly



FIG. 1. Cervical tissue showing decidual reaction at the peaks of the mucosal folds.



FIG. 2. Decidua cells with villus nearby (enlarged from Figure 1).

removed. After the removal of a few strongly adherent remnants from the wall, and after tight packing of the cervix and the vagina, the bleeding stopped.

A transfusion was given. The blood findings before the transfusion were: 2 million red blood cells and 57 per cent hemoglobin. Recovery was uneventful. The packing was removed on the third day. During the following days there was abundant bloody discharge.

Five weeks later the portio vaginalis appeared normal on inspection. The next menstruation came six weeks after this event. The histological examination of one of the removed tumor particles revealed, in contrast to the preliminary diagnosis, a clear picture of a pregnancy in the cervix.

Histological report (Figs. 1 and 2) by Dr. Alfred Plaut was as follows: The slide is stained with hematoxylin-eosin. There is cervical tissue which can be definitely recognized by characteristic glands and by the surface epithelium. The cervical stroma, however, is completely altered by edema, inflammation and hemorrhage. Numerous, large, compact, mononuclear cells are scattered through the stroma. They obviously are decidua cells. No

chorionic tissue can be found in the cervical tissue. Other pieces, however, consist of young placental tissue. The double layer of epithelium is distinct on most of the villi. There are rather large masses of chorionic epithelium. There also is a fragment of the fetal sac.

An implantation of the ovum in the cervix can be assumed only if proof can be given that the site of the placenta lies exclusively within the cervix. The most important prerequisite for this evidence is the possibility of delimiting anatomically the site of the placenta within the cervix, from the isthmus and the corpus. The discussion of a few anatomical facts concerning the cervix and the isthmus in the pregnant and non-pregnant uterus seems imperative in understanding this issue.

Isthmus in Non-pregnant Uterus. The isthmic canal forms the upper continuation of the cervical channel; together with it, it constitutes the tubular portion of the uterus. Its boundary towards the uterine body is defined macroscopically by the

orificum isthmi internum, i.e., the transition of the tubular portion into the triangular slit of the corporeal cavity. Looking at a frontal section through the uterine cavity in its premenstrual stage, the increase in thickness of the mucosa which is early developed in the isthmus, is not so marked in this part, caused by the absence of a functional layer, especially of the corporeal mucosa. Aside from these macroscopically visible characteristics, the demarcation of the isthmus towards the corpus, as well as towards the cervix, can be verified only microscopically. The isthmus is lined with a sort of mucosa similar to that of the corpus, but with important and obvious differences which need not be discussed in detail at this point. The phasic change of the isthmical glands is rudimentary in comparison with that in the corpus. The isthmic mucosa remains almost the same low layer even during the menstrual cycle, and in no way joins in the formation of a nidation bed. In the gross the isthmus forms a unit with the cervix, but histologically it forms a unit with the corpus.

Isthmus in the Pregnant Uterus. In pregnancy, too, the development of the isthmic mucosa lags far behind that of the corpus. The decidual reaction of the isthmus is generally very scanty or may be completely absent. The morphologic unity of the isthmus with the cervix is regularly abandoned at an early stage of pregnancy, whereby the tubular isthmic segment becomes gradually unfolded, forming ultimately the lower pole of the breeding cavity harboring the fetal sac. Though it is still claimed by many that the unfolding starts only from the fourth month, investigations by Stieve have proven that the unfolding of the isthmus starts as early as the third month and is complete at the end of the third month. The unfolded isthmus is then known as the lower uterine segment. Macroscopically, its demarcation towards the cervical canal is now definitely possible in that the unfolding stops abruptly at the orificium cervicis internum. Histologically,

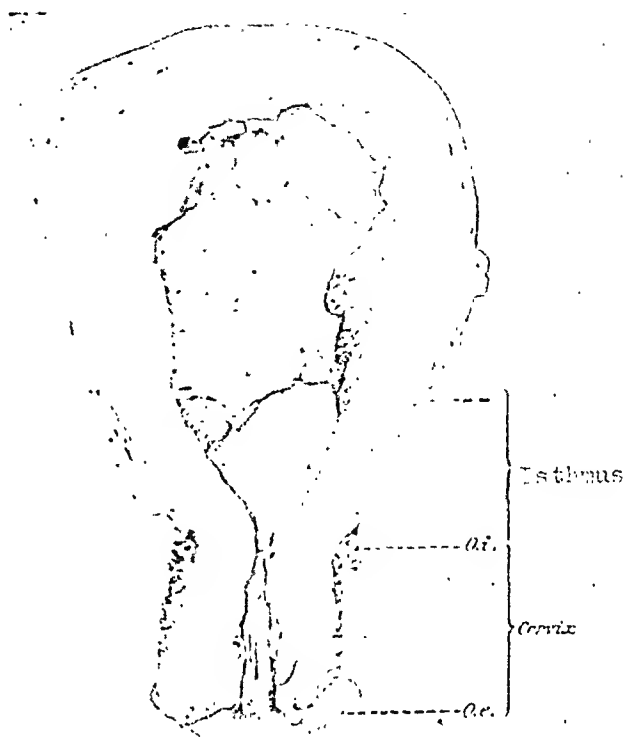


FIG. 3. Pregnant uterus two to three months showing thin mucosa in lower uterine segment (isthmus) (according to H. R. Schmidt).

the isthmus can be delimited towards the cervix proper at any time during pregnancy, exactly as in the non-pregnant uterus. Upwards, against the corporeal mucosa, however, the demarcation of the isthmus after its absorption into the corporeal cavity is harder to demonstrate. When a decidual reaction in the isthmus is absent, a differentiation between the thick gestational endometrium and the thin isthmic mucosa is clearly apparent even macroscopically. (Fig. 3.) The ability to differentiate between isthmus and corpus, however, varies widely and becomes problematic even on microscopic examination, with progressing pregnancy.

Isthmic Placenta. If occasionally this area of mucosa becomes the site of a placenta, and the structure of the mucosa is thereby changed to a great extent, an exact delimitation between the isthmic and corporeal mucosa becomes almost impossible. However, such a placenta can unquestionably be recognized as an isthmus placenta on account of its location at the lower pole of the uterine cavity. Formerly it was thought that one would be able, on

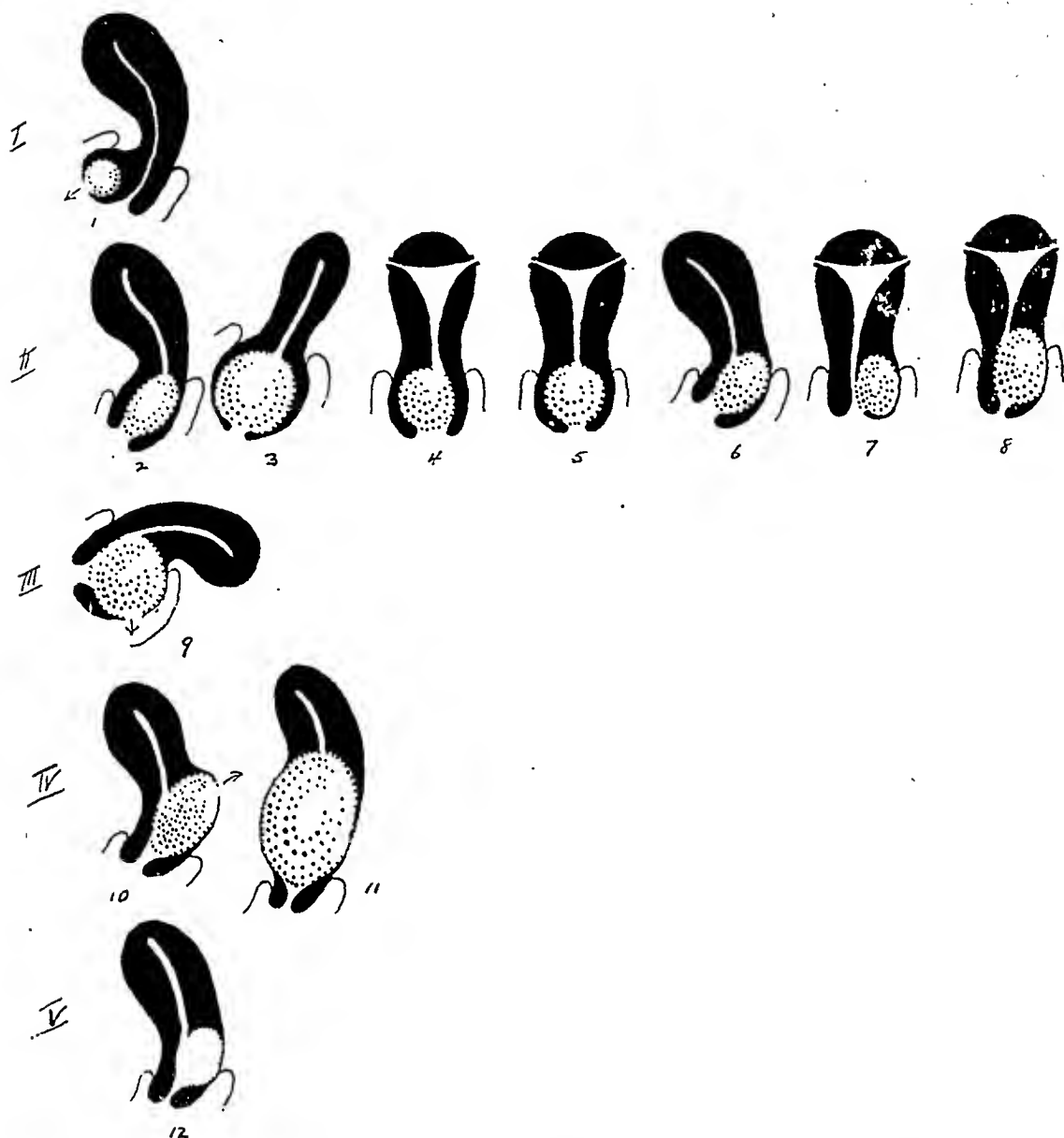


FIG. 4. Diagrams of Cases 1 to 12. I, 1, Otto; II, 2, d'Aprile, 3, Fearl, 4, Frachtman, 5, Gheorgiu, 6, Gimpelson, 7, Schneider, 8, Stresoff; III, 9, Gergely; IV, 10, Szenteh, 11, Meyer; V, 12, Steinbiss.

account of certain external signs, regarded as characteristic, to determine the boundary between the isthmus and corpus, even when the microscopic examination failed to do so. These signs included the course of the circular vein, the reflection of the peritoneum and the site of the entrance of the uterine artery. Thorough investigations, however, have shown that these characteristics are unreliable. Furthermore, the fact that a contraction ring or even a larger contracted portion of the uterus can

be distinguished above the isthmic placenta, can in no way be used as a demarcation line between isthmus and corpus.

From these considerations it follows that a placenta, primarily developed within the isthmus, having its origin in the implantation of the ovum in the isthmic mucosa, cannot practically be differentiated from a secondary isthmic placenta originating from the corporeal mucosa and trespassing secondarily on the isthmus, once the placenta spreads over a large area.

Cervical Placenta. The conditions are similar in the case of cervical placenta. The gross anatomical site of the placenta in the cervix, the rim reaching far down, close or right down to the external orifice, permits the exclusion of any doubt in the diagnosis of this rare placental site. The establishment of the fact, however, that the placenta is situated in the cervix, is not sufficient to answer the question of a cervical implantation of the ovum in the affirmative. This is only possible, as already mentioned, if the placentation is completely and exclusively limited to the cervix. It turned out in the study of the literature that in cases of placentas developed beyond the third month of gestation, it was impossible to prove that the upper limit of the placentation lay within the cervical mucosa. Once the development of the placenta has progressed so far that the isthmus is, for the most part, involved in the chorionic invasion, we are no longer justified in terming the cervical placenta a primary cervical placenta. In the inexact interpretation of the concept of cervical placentation lies, in my opinion, the most frequent cause for misunderstanding, when the question of cervical pregnancy comes up for discussion. We should not designate as a cervical pregnancy a pregnancy which, on account of its gross anatomical appearance apparently lies in the cervical portion of the uterus, but only that kind of pregnancy which originated through implantation of the ovum in the cervical mucosa (sometimes called true or primary pregnancy).

Corpus—Isthmus—Cervix Placenta. As in the first series of distal implantations of the ovum, reviewed up to the year 1926, we find in the cases of alleged cervical pregnancies published since, a considerable number which ought to be put into the group of corpus-isthmus-cervix-placenta (listed in Table III). It may be strongly emphasized at this point that the possibility of a primary cervical implantation with consequent proximal extension into the corporeal mucosa in a number of these

cases, should not be denied nor can it be ruled out. The following three typical cases of this group demonstrate that these cases can in no way be considered as cervical implantations, because of lack of evidence of a total and exclusive placentation in the cervix.

1. Crousse published a case as a cervical pregnancy which bled to death in the third to fourth month of gestation after separation of the placenta. The postmortem examination of the uterus revealed without difficulty that, although the placenta reached distally right up to the external orifice, it extended upward beyond the isthmus and into the corpus. As in so many similar cases, a histological verification of the boundaries of the placentation was not even attempted.

2. Reist described the case of a five-months old cervical gestation which terminated by miscarriage. The digital exploration of the uterine cavity after removal of the fetus revealed changes which were reconstructed in a drawing. The cervix formed a huge, loose, thin-walled sac, above which a firm, thick-walled uterine body, the size of a fist, could be felt. Although any anatomical verification of the cervix-corpus boundary is lacking, this case is presented by the author as a case of "rare ectopic pregnancy in form of graviditas cervicalis primaria." In contrast to these two cases representative of a group not examined anatomically, but classified as cervix-corpus placenta, there is one case of histologically examined cervix-isthmus placenta.

3. Kleiner reports a two to three-months old pregnancy, in which the uterus had to be extirpated on account of a severe hemorrhage. The clinical picture as well as the far distal site of the placenta suggested the possibility of a primary cervical pregnancy. The microscopic examination, however, disclosed definitely that the placentation had trespassed the area of the cervix upward, and had involved the entire isthmus.

Cervical Implantation. The placental site in the cervix may not or may only barely trespass the boundary between the cervix and isthmus if the development of the placenta is to be correlated to an implantation of the ovum in the cervix. On the extirpated or postmortem specimen the

microscopic evidence of this boundary is indispensable for the diagnosis of a cervical pregnancy. In case of an early pregnancy situated in the distal portion of the cervix, and accessible only to clinical exploration, the presence of an intact upper portion of the cervix-isthmus-canal is sufficient, if considered in connection with the other observations (age of pregnancy, size of the ovum, measurements).

TABLE I
PROVED CERVICAL IMPLANTATIONS

Author	Year
1. Schneider	1926
2. Stresoff	1927
3. Steinbiss	1928
4. Meyer	1929
5. Szentch	1933
6. Otto	1934
7. Gheorgiu and Protopopescu	1935
8. Gergely	1935
9. Gimpelson	1936
10. D'Aprile	1937
11. Pearl	1945
12. Frachtman	1946

The twelve cases of cervical implantation meeting such requirements are listed in Table I in the order of their time of publication. Table II includes those cases to which a certain probability of being cervical pregnancies may be ascribed on account of clinical observation. In these cases, however, anatomical examinations are completely lacking, or those presented are insufficient.

TABLE II
CLINICALLY POSSIBLE CERVICAL PREGNANCIES BUT WITHOUT ANATOMICAL EVIDENCE

Author
1. De Michele
2. Tropea (first case)
3. Bolaffi
5. Schürger
6. Wittrin
7. Studdiford (second case)*

* This case of Studdiford, according to my personal belief, represents a fairly certain case of a cervical implantation because of the fact, not known to occur in any other condition, that there was a rupture into the vaginal fornix. Since, however, the case lacks any other anatomical data except (1) pregnancy in the cervix and (2) rupture into the vagina, I did not venture to classify it as a proven cervical implantation.

Pathological Anatomy. Upon attempt to give a comprehensive picture of the pathological anatomy of cervical gestation, it

must be emphasized that this presentation suffers from the shortcomings of too few observations and from the regrettable fact that the reports on histological examinations are short and incomplete. Systematic investigations of this rare form of pregnancy are almost completely lacking. The existing findings are furthermore inadequate because they are, by nature, confined to microscopic examinations of the placental bed following separation of the ovum, at which time the tissue to be examined was disarranged through formation of hematoma and other injuries. The histologic examination of a case of intact cervical pregnancy in an early stage, is still lacking.

TABLE III
CORPUS-ISTHMUS-CERVIX PLACENTAS

Author
1. Jolkin
2. Gänsbauer
3. Tropea (second case)
4. Kleiner
5. Vaudescal
6. Andrei
7. Crousse
8. Tarleton
9. Desirotte
10. Reist
11. Studdiford (first case)

The more distally in the cervix the pregnancy is located and the earlier the time it comes to our attention, the more convincing and simple is the proof of cervical implantation. More than half of the cases reviewed here are observations

TABLE IV
CERVICAL ABORTION

Author
1. Hyslop
2. Bacialli

of pregnancies in the vaginal portion of the cervix between six and eight weeks old. However, there was also a case of a twelve-weeks old pregnancy in the vaginal portion (published by Gergely). The remaining cases concern cervical pregnancies of ten to twelve weeks, which reach upwards to the isthmus.

Dividing the cervix for descriptive purposes into anterior, posterior and two

lateral walls, we find only in one single case the site of the pregnancy in the anterior wall (Otto). In all other cases the posterior and lateral walls of the cervix were involved in the placentation, with the exception of two cases (Gheorgiu, Meyer), in which annular placentation was observed. This distribution of the placental site is in contrast to the one in the corpus where anterior and posterior walls are equally often included as sites of implantation.

Arranged according to age and topography, the twelve cases of cervical pregnancy can be comprised in the following five groups (Fig. 4):

1. *Case of Otto*: The most distally located pregnancy ever observed is described by Otto, situated in the anterior cervical lip. It was a six-weeks old pregnancy which, like a tumor, expanded the anterior wall of the vaginal portion, forming a cherry-sized nodule. This extremely distally situated ovum had, at the time of the observation, perforated into the vagina through a lentil-sized opening, causing a severe hemorrhage. The amputation of the vaginal portion and its histological examination by serial sections disclosed an exclusive and complete placentation within the cervix.

2. *Cases of Aprile, Fearl, Frachtmann, Gheorgiu, Gimpelson, Schneider, Stresow*: This group includes the majority of cases here described, and presents what might be considered the typical picture of cervical pregnancy. These are the cases of six to eight-weeks old pregnancies, almost exclusively, or for the most part developed within the vaginal portion of the cervix. The site of the placentation reached downward right to the external os (or within 1 to 6 mm.) and was separated above from the corpus cavity by an intact isthmic canal. In four cases this was proved by clinical observation which disclosed above the site of placentation the presence of a canal either closed or open to a Hegar probe No. 5. In two cases of this group, histologically examined after extirpation of the uterus, the isthmus appeared free of chorionic elements. In one case (Fearl) a statement could not be found regarding a cervical-isthmic canal above the ovular bed, nor was the upward boundary defined histologically. Nevertheless the pregnancy has to be considered as confined to the vaginal por-

tion of the cervix from the following facts. The cervix was enlarged to a tumor filling the whole vagina. The tumor consisted of a thin shell of cervical tissue and enclosed the fetal sac which reached right down to the external os. As the fetus was found to measure 15 mm. in length, corresponding to an age of seven weeks, the external dimensions of the ovum could hardly have exceeded 40:35 mm. and, therefore, must have been lying within the distal portion of the cervix.

At the time of observation, in five cases the fetal sac was still intact within the cervix; in the remaining two cases there was only a hemorrhagic, friable tumor present in the cervical canal, the true nature of which became evident only after microscopic examination. On clinical examination, the vaginal portion was in all cases spherically or pear-shaped distended, and grown to the size of an egg. Aside from the case of Fearl in which the placenta was moderately adherent, and from my own case, in which the complete and well preserved ovum could be removed without difficulty from the surrounding cervical wall, all other cases had the ovular tissue firmly anchored in the wall and could be separated from their bed only with great difficulty or not at all. The defect remaining in the cervical wall was each time like a crater, and was as impressive as the thinning of the cervical wall in the center of the placentation. On recalling the anatomical picture of the case we observed twenty years ago, two features stand out strikingly. The first was the presence of a canal lined with a pale mucosa proximally adjacent to the hemorrhagic bed of the ovum in the portio; the other, the perplexing fact that the examining finger within the cervical cavity and the palpating thumb within the vaginal fornix could almost touch each other, and were separated only by a paper-thin cervical wall. This thinning of the fibromuscular wall which would necessarily have led to a rupture into the vaginal fornix within a very short time, had pregnancy continued, has also been pointed out in other cases. For instance Stresow reported this thinning at the same site, and Gimpelson and Steinbiss on the posterior wall of the cervix, immediately before its rupture into the cul-de-sac. The trabecular structure at the base of the destroyed cervical wall has likewise been pointed out by some authors (Schneider, Steinbiss, Meyer).

3. The case of Gergely is a twelve-weeks old pregnancy, also exclusively situated in the vaginal portion of the cervix. The patient was seen eight days after she had suffered an injury (fall on coccyx). At that time the vaginal portion was enlarged to a fist-sized tumor. The anterior wall of the portio was of normal thickness, the posterior wall was thinned out to 2 to 3 mm. A tear, 9 cm. in length reached in the posterior cervical wall from the external os to the posterior vaginal fornix. The cavity of the ovum within the vaginal portion was separated from the cavity of the retroflexed uterine body by a canal passable by a Hegar probe No. 7.

4. The cases of Szenteh and Meyer are, in contrast to the preceding cases, characterized by the fact that the pregnancy was predominantly situated in the upper portion of the cervix. In the case of Szenteh it was a cervical pregnancy over eight weeks old, which on vaginal examination could be felt as a protrusion the size of a goose egg, to the right of and below the enlarged uterine body. The vaginal portion proper was apparently not involved. The pregnant cervix was ruptured into the abdominal cavity, the tear, 2 cm. long, taking place in the posterior wall. The case was examined histologically and it was reported that the whole fetal sac lay in the cervical canal. Only an abstract of the original paper was accessible to me, and this does not give any clues on the kind of determination of the upper boundary of the cervix. However, as a rupture of the cervix at so early a stage of pregnancy is not known, except in cervical implantations, and as all signs of the description speak in favor of a cervical pregnancy, this case should, to my mind, be recognized as a cervical implantation.

The second case of this group (case of Meyer) presents the furthest developed pregnancy in the upper part of the cervix, confined completely and exclusively to the cervix itself, as shown on histological investigation. This was a twelve-weeks old intact cervical pregnancy, in which the vaginal portion, though shortened, was preserved and continuous with an oval body corresponding in shape and consistency to a three months' gestation. Placed above this tumor, the uterine body could be palpated. As a result of a thorough microscopic examination of the extirpated organ, evidence was established to the effect that the placentation did

not enter the isthmus. Proof of a placentation solely restricted to the cervix has not successfully been offered in any case of cervical placentation of more than three month's gestation.

5. Although the case of Steinbiss would fit into one of the above groups on account of its topography, it should be classified by itself because the clinical history was very indefinite. The case was recognized as a cervical pregnancy only on postmortem, and then underwent a thorough anatomic-histologic work-up. There was a 4 to 3.5 cm. round, for the most part sharp-edged defect in the tissue of the posterior wall of the cervix, reaching in depth right down to the peritoneum, and seeming on the verge of rupture. Proximally the isthmus was included to a small extent in the placentation. This, however, was so insignificant in comparison with the defect in the cervix that the case can, without hesitation, be considered one of cervical implantation.

Histology. Histologic investigations on the early implantation of the ovum and its development within the cervical mucosa are completely lacking to date. This may be due to the fact that ova burrowing in the cervical mucosa superficially, are often destroyed (by hemorrhages into the ovum bed) and extruded as a whole. It is only when the villi, after penetration of the mucous membrane have invaded the musculature, that the ovum is attached more firmly and harder to separate. This would explain why ova up to the sixth week have not been observed, being expelled at an early stage with relatively insignificant and not characteristic symptoms.

The true cervical pregnancy shows all the characteristic signs of an ectopic gestation caused by the inability of the parent tissue to provide an adequate bed for the developing ovum. Like the mucosa of the tube, the cervical mucosa does not undergo definite gestational changes or decidual transformations. Occasionally, under the influence of gestational hormones, the formation of decidual cells may take place at the portio, in the presence of erosions, in cervical polyps and in the inflamed cervical mucosa. In the absence of inflammatory

signs, however, the appearance of decidual reaction in the cervix in the course of corporeal pregnancy seems to be rare. Stieve, who has done the most thorough investigations regarding the conditions in the cervix in normal pregnancy, reports that he never came across definite decidual cells in the cervix. However, like the tube, the cervical mucosa produces decidual cells, single and in larger groups, as an effect of hormonal and local reaction, once the ovum has embedded itself there. In no case of microscopically examined cervical pregnancy is the statement lacking that decidual cells were observed. Definite decidual reaction can be found in the immediate vicinity of the ovum, especially in the stroma at the peaks of the mucosal folds. (Figs. 1 and 2.) In my own case large plaques of decidual cells in units were found in the cervical mucosa at the periphery of the site of the placentation, while in the central parts, where the mucosa was mostly destroyed, no decidual cells could be seen. This reactive cell formation, produced through the presence of the ovum, can in no way be considered equal to the transformation of the endometrium into a true decidua graviditatis. Today it is generally thought that the thick decidual layer in the mucosa corporis first takes care of nourishing the ovum as long as it is in the histotrophic stage. The second important function of the corporeal decidua consists in building a protecting wall against the invading, tissue-dissolving, chorionic villi and mobile trophoblast cells, as soon as the second stage, the hemotrophic stage of feeding the ovum sets in. At this stage the chorionic villi absorb the nutritive elements from the maternal blood after erosion of the maternal vessels. The decidua basalis endometrii represents a regulating factor of the adequately functioning maternal tissue, checking the reckless, destroying advance of the villi. Through the production of an antitryptic enzyme a balance of powers is effected which prevents the invasion of the trophoblastic masses into the depth of the mucosa

and musculature of the wall. As a consequence of the lack of this protective device in cervical pregnancy, the tissue surrounding the ovum is digested and destroyed without inhibition, exactly as in tubal pregnancy. In all cases examined, specifically with this point in mind, the deep penetration of the proliferating chorionic villi into the fibromuscular layer of the cervix could be established microscopically. We found the cervical wall infiltrated by large trophoblast cells, rich in protoplasm, partly in chains, partly isolated, particularly abundant around the vessels. Not their mere presence but their remarkably large number presents the pathognomonic status. Aprile sees the villi invading the blood vessels and the musculature. Otto observes the cervical musculature in the vicinity of the ovum bed strongly interspersed by chorionic villi and described young, well preserved chorionic villi within the lumen of the vessels of the cervical tissue. Steinbiss finds chorionic elements in all layers and villi implanting themselves deep in the musculature. The defect of the tissue thereby produced, already macroscopically very impressive, resembles the destruction of the tissue brought about by a malignant tumor, for which cervical pregnancy is occasionally mistaken. Neither with tubal pregnancy nor with placenta accreta do we come across such penetrating, circumscribed defects of tissue, confined to a relatively small area, as occurs in cervical pregnancy through the melting away of the thick cervical wall adjacent to the ovum. The vessels of the cervix show fibroid degeneration of their wall and infiltration by villi and trophoblast cells. The lumina of the vessels are considerably dilated and engorged with blood. The fibromuscular tissue of the cervix occasionally shows edema, swelling, fibroid degeneration, necrosis, hemorrhage, and small cell infiltration. With the tapping of larger vessels, especially with the erosion of arteries, the gestation sac gives way under the increased hemodynamic pressure and a flow occurs

through the external orifice towards the outside. Hemorrhages caused in this way can be found at an early stage in the clinical history of some patients. With further development of the ovum, its attachment to the ground of the implantation cavity becomes more intimate and the opening of large vessels is necessary to bring about the separation of the entire ovum. These large vessels are numerous in the deeper layer of the cervical wall. With their erosion, hematoma forms around the ovum and interruption of pregnancy by abortion takes place (internal rupture of the gestation sac). The second possible ending of cervical pregnancy is that the wall destroying growth of the chorion towards the periphery leads to a complete consumption of the ovum bed and to a perforation of gestation towards the outside (external rupture of the gestation sac, cervical rupture). Of the twelve cases of cervical pregnancy mentioned, four were intact at the time of their observation, five terminated by internal, and three by external rupture of the gestation sac.

Decidua Sympathica. The uterine mucosa in cervical pregnancy reacts to the presence of a live ovum with the formation of a decidua sympathica, as it nearly always does in ectopic pregnancy. But we find only in six cases microscopical examinations carried out in this respect. In four cases a typical decidua was present. In the remaining two cases none was found, explained by the fact that between termination of the pregnancy and the histological examination of the specimen, two and four weeks, respectively, had elapsed.

Clinical Symptoms. In search of characteristic symptoms of cervical pregnancy before the occurrence of severe hemorrhage, it must again be emphasized that clinical records are still more scarce than anatomical data. Regarding preceding gestations all possibilities are presented in the cases of cervical pregnancies. With most women one or more pregnancies had preceded, some of which had terminated with a spontaneous abortion and some with a delivery in term. Only in one case

(Meyer) the present pregnancy was the first. Some women complained of pain in the lower abdomen or back, while in some cases the first weeks of pregnancy were symptomless. Most frequently one comes across statements of irregular bleedings after cessation of the menstruation; for example in the case of Aprile, hemorrhages occurred fourteen days after the skipped menstruation. Irregular, slight hemorrhages starting in a later stage were frequently observed. In my own case, cyclic menstrual bleedings continued in no connection with bleedings from the ovum bed. In the end, it was always the violent hemorrhages following the complete separation of the ovum or the rupture of the cervical wall which led to medical intervention.

Diagnosis. Of special interest is the variety of diagnoses which were made before knowledge of the true facts of the cases. If the pregnancy in the vaginal portion of the cervix happened to be observed at a time at which the ovum was not yet separated from its surrounding, then the right diagnosis of cervical pregnancy was made (Gimpelson, Stresow). If, however, the case was examined after separation of the ovum, but still during its retention within the cervix, then the first impression was that of a cervical abortion (Schneider, Aprile). If on thorough examination a violently bleeding, crater-like defect was found in the cervical wall, the retained hemorrhagic ovular remnants were not recognized as such, and the obvious diagnosis was malignant, cervical tumor (Aprile, Gheorgiu, Frachtman). The pregnancy that ruptured through the anterior cervical lip was first referred to the hospital as a bleeding varicose vein of the portio (Otto). In the hospital the diagnosis changed to that of a cervical metastasis of a chorion epithelioma, and the uterine cavity was searched for the primary source of this disease. The rupture of the cervical pregnancy into the abdominal cavity was misinterpreted as ruptured tubal pregnancy (Szenteh). A blood mole, attached all around the cervical wall in

the course of cervical pregnancy, aroused the impression of a necrotic fibroid (Gheorgiu). In the patient of Steinbiss who died of a secondary hemorrhage four weeks after completed abortion, an autopsy was performed in an institute for Forensic Medicine, because of suspected criminal abortion, and not until then was the right diagnosis of cervical pregnancy made. The case exposes the occasional forensic significance of distal ectopic pregnancy.

Differential Diagnosis. In consequence of the multiformity in which the cervical pregnancy may appear, no generally valid rules for diagnosis can be given. One is easily misled to take a cervical pregnancy for an abortion of a corporeal pregnancy into the cervix, which it resembles to a certain degree on digital exploration. In the differential diagnosis of a cervical pregnancy versus a cervical abortion, one has to keep in mind that in the case of an abortion from the uterine cavity into the cervix, violent, painful uterine cramps and hemorrhages preceded the complete separation of the ovum. At the time when the abortion is essentially over, but the external os has not opened and a contracted body can be felt above the dilated cervix, no essential hemorrhages or pains are present. On the other hand no uterine cramps accompany cervical pregnancy, and hemorrhage is increased by digital examination, or brought about by it for the first time. While in cervical abortion the elastic pressure of the dilated cervical wall has the tendency to expel the retained ovum through the external orifice, in cervical pregnancy no such tendencies exist, in consequence of the severe damage to the fibromuscular wall of the cervix. Beyond that the ovum is mostly held tight within the cervical canal by the chorionic villi deeply anchored within the wall.

Hemorrhage. Whether a cervical pregnancy terminates spontaneously, be it by rupture of the extremely thinned cervical wall, be it by internal rupture of the gestation sac (abortion), or whether it is interrupted artificially, the leading, and

most alarming symptom is always the violent hemorrhage associated with it. While the blood supply of the non-pregnant cervix is already abundant, in normal corporeal pregnancy a considerable increase in size and a new formation of vessels in the cervix takes place at an early stage, as Stieve has demonstrated. The presence of the growing ovum and the development of the placenta in the cervix naturally causes a strong local hyperemia. The inability of the maternal tissue to resist the villi leads to an uninhibited and reckless opening of the blood vessels. The direct insertion of the placenta into the muscularis, without interposed mucous membrane, results in an unphysiological and inadequate separation mechanism of the placenta, typical of ectopic gestation and of placenta accreta. The lack of a physiological vascular occlusion, as consequence of the damaged and defective musculature of the cervical wall, the fibrinoid degeneration of the vascular wall and the loss of elastic elements in the vessels associated therewith, favor in every imaginable respect a violent, acute and life-endangering hemorrhage in the moment of rupture of the gestation sac. The same factors are to be made responsible for the defective thrombus formation in the vessels, which, in some cases can lead to severe hemorrhages weeks after expulsion of the ovum (Schneider, Gimpelson) and even to fatal secondary hemorrhage (Steinbiss).

Therapy and Result. The spontaneous rupture of a cervical pregnancy through the anterior cervical lip (Otto) was cured by amputation of the cervix, and the spontaneous rupture into the pouch of Douglas (Szenteh) was successfully treated by a supracervical amputation of the uterus. In the case of Gergely the extremely thinned and dilated posterior wall of the portio ruptured after the patient had fallen on her coccyx. The hematoma that consequently developed was only removed eight days after this mishap and hemostasis was achieved by tight packing of the cervix. The patient

died fourteen days later of an ascending peritonitis. In the case of Meyer, (the three months old pregnancy in the upper portion of the cervix) *seetio parva* was attempted for the purpose of artificial interruption of the pregnancy. The hemorrhage in the course of operation could not be stopped by packing or by clamps. Only by extirpation of the uterus, leaving the lowest portion of the cervix, could the hemorrhage be checked and the patient cured. In all other cases a violent hemorrhage took place during or immediately after removal of the ovum or of the remaining fragments of the ovum, which, in the case of Gheorgiu necessitated the extirpation of the uterus. In the remaining cases the hemorrhage could be stopped by packing and ligatures, sometimes only after repetition of the packing during the following days. In the cases of Schneider and Gimpelson, life-endangering secondary hemorrhage occurred after two weeks caused by detachment of the vascular thrombi, which in my own case could be cured by packing, and in the case of Gimpelson through extirpation of the uterus. Only in one case, not under medical care (Steinbiss) a fatal secondary hemorrhage from eroded vessels of the site of placentation, occurred four weeks after spontaneous abortion.

Etiology. The same consideration with regard to the etiology of cervical pregnancy taken into account twenty years ago, can still be brought forth today. Between fertilization of the ovum and its implanting, several days elapse, during which the ovum passes through the so-called maturation for implantation; only at the end of this period is the ovum capable of penetrating into the maternal tissue as a result of the development of its invasive powers. This implantation term depends on a certain degree of differentiation of the ovum. The maturing process takes place mainly during the downward passage of the ovum through the tube. The presumed time of this process is seven to ten days.

The site of implantation is determined

by two principal factors: the tempo of the travel of the ovum and the duration for the ripening for implantation. Under normal conditions, free traveling of the ovum and maturing process for implantation are synchronized in such a way that at the time the ovum has gained its implantation maturity, it is located exactly in the uterine body. If a shifting of either of these factors against the other takes place, it results in a pathological nidation. If the transport of the fertilized ovum is delayed or suspended by obstacles within the course of the ovum, the pathologically proximal insertion of the ovum takes place. The same is bound to happen on normal passage but too early onset of implantation maturity. If, however, the travel of the ovum is accelerated and the implantation maturity normal, or if the traveling time is normal but the maturation delayed, the prerequisites for a pathologically distal insertion of the ovum are present. The implantation maturity is a function of the ovum; the travel of the ovum is a function of its environment. One may assume that the implantation maturity is subjected only to a narrow range of variation as it is a biologically and phylogenetically deeply rooted process. The transportation of the ovum on the other hand, secured by the peristalsis of the tube, the contractions of the uterus and the ciliary current of the epithelium of the mucosa is more subjected to variations. How often a defect of these functions or an obstruction of the tube leads to a proximal ectopic pregnancy is well known. Excess in the other direction, i.e., too rapid transportation of the ovum leads to a pathologically distal implantation of the ovum.

The ovum is, so to speak, not discriminative in the choice of its implantation ground. Having gained the adequate invasive power at the time of implantation maturity, it implants itself on the surface of the mesenterium as well as on the serosa of the uterus, on the ovary as well as in the tube and cervical mucosa. While for the occurrence of a pathologically

proximal insertion of the ovum, conditions impairing its transport form the most frequent cause, for the causation of a pathologically distal pregnancy, especially a distal ectopic, the possibility must be left open that the ovum becomes caught by a delayed implantation maturity occurring in an explosion-like manner in the last moment just before its extrusion from the uterus.

CONCLUSION

Herewith an attempt has been made for the first time, to put together the anatomical and clinical data of distal ectopic pregnancy on the basis of a relatively small and inadequately described number of cervical pregnancies as given in the world literature. Particularly in Anglo-American literature, only one case of cervical pregnancy can be found published recently by Fearl. The present case observed by Frachtmann is the second of its kind in American literature definitely proven as cervical implantation. It would be extremely desirable to have cervical pregnancies recognized in their early stage and the diagnosis supported by thorough anatomic-histological investigation. Our knowledge of this rare and interesting gestation type, almost always associated with violent symptoms, would, thereby, be put on a broader basis.

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A COMPARISON OF SILK AND NYLON AS SUTURE MATERIAL

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SURGICAL literature is replete with articles concerning various types of materials used for sutures and liga-



FIG. 1. Gastrointestinal anastomosis performed with nylon, forty-eight hours postoperatively.

tures. Since the detailed description of the "silk technic" by Halsted¹ in 1913, there has been constant controversy regarding the relative advantages and disadvantages of absorbable versus non-absorbable suture materials. Until some ideal material is discovered, having the absorbability of catgut sutures, and the relatively low tissue reaction of non-absorbable sutures, each of these materials will continue to have its exponents.

With the introduction of nylon, a synthetic product, there was presented a substitute for silk, for which various advantages were claimed: (1) greater tensile strength; (2) greater elasticity; (3) more constant uniformity in diameter; (4) smoother surface; and (5) less reaction in tissues.

The results of several investigations have been reported using nylon in skin, muscle and fascia.²

The present study is concerned with a comparison of silk versus nylon as suture material in intestinal anastomosis, and with an evaluation of the safety in the use of nylon.

EXPERIMENTS

Procedure. The experimental procedures were carried out on eight healthy dogs. These were divided into two groups with four animals in each group. The usual aseptic operating room technic was employed. Nylon was used in Group I, and silk in Group II.

Each material was used in performing a two-layer gastroenterostomy. A moisture and serum-proof braided nylon suture, measuring 0.006 inches in diameter,* was used in Group I. This corresponds to a No. 0000 catgut suture. A similar braided silk suture,** of the same diameter as the nylon, was used in Group II. Correspondingly heavier grades of the same materials were

* #C Deknatel surgical nylon suture.

** #C Deknatel surgical silk suture.

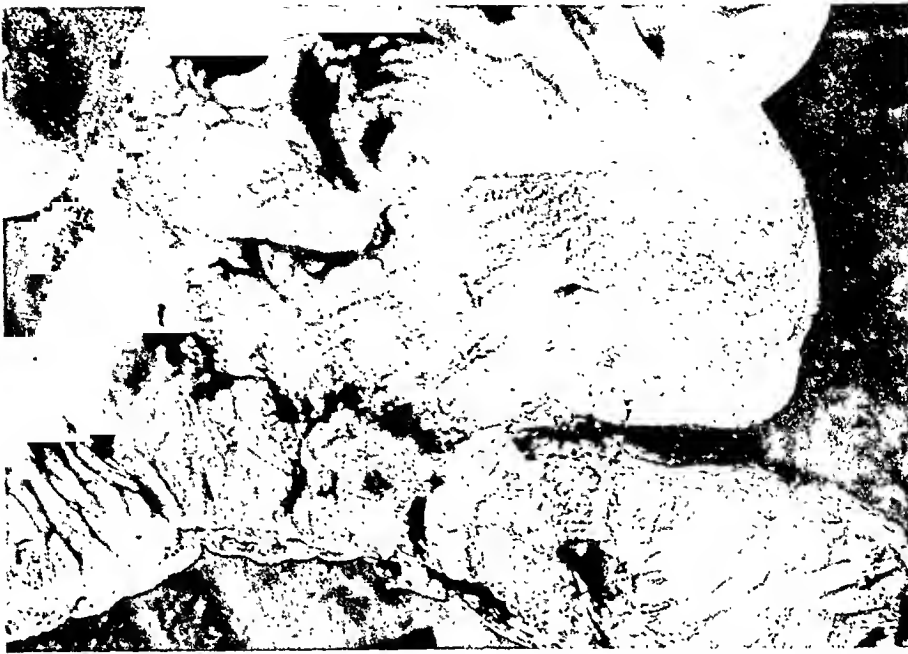


FIG. 2. Gastrointestinal anastomosis performed with silk, forty-eight hours postoperatively.

used in closing the peritoneum, fascia, muscle and skin.

Postoperatively, the animals were treated symptomatically and were given the usual parenteral fluids. After forty-eight hours they were offered a soft diet, and then other foods were given as tolerated. The animals were sacrificed at different intervals postoperatively, namely, forty-eight hours, ninety-six hours, nine days and thirty days. The organs were examined grossly and sections were taken from various regions of the anastomoses for microscopic studies.

Findings. Operative: It was found that nylon, whether wet or dry, seemed to maintain its body texture better than did silk. It handled more easily and was less likely to break during the process of tying. The postoperative course of the animals was uneventful, with no apparent discomfort or rise in temperature beyond the usual expectations.

Postmortem. On gross examination of the anastomosis, peritoneum, fascia, muscle and skin in each of the animals, there was no significant difference that could be attributed to the type of material employed. The anastomotic stoma were intact in all animals. Those autopsied at forty-

eight and ninety-six hours showed a mild degree of serosal congestion with occasional slight ecchymotic areas, attributable to the relatively recent operative manipulation.



FIG. 3. Stoma of gastrointestinal anastomosis performed with nylon, ninety-six hours postoperatively.

(Figs. 1 and 2.) The intact, well healed stoma of the ninety-six hour nylon anastomosis is shown in Figure 3. Those animals which were examined after nine days and thirty days showed well healed anastomoses. (Figs. 4, 5, and 6.)



FIG. 4. Gastrointestinal anastomosis performed with nylon, nine days postoperatively.

The microscopic findings of* the anastomoses with both silk and nylon were as follows: "Sections through the anasto-

the clear zone there is the zone of reaction. In the 48-hour and 96-hour nylon specimens, there is a typical early foreign body



FIG. 5. Stoma of gastrointestinal anastomosis performed with nylon, nine days postoperatively.

moses show suture material in both the submucosal and muscular layers of the gastrointestinal wall. In view of the fact that many of the sectioned strands of suture were lost in the process of preparation of the slides, the sutures are represented by only a few persistent strands of material, with an adjoining clear area, the latter representing the previous site of the lost fragments. Directly surrounding

* Reported by Dr. S. H. Polayes, Department of Pathology, Cumberland Hospital, Brooklyn, N.Y.



FIG. 6. Gastrointestinal anastomosis performed with nylon, thirty days postoperatively.

reaction, with a moderate infiltrate of polymorphonuclear leucocytes and occasional round cells. The silk specimens of the same

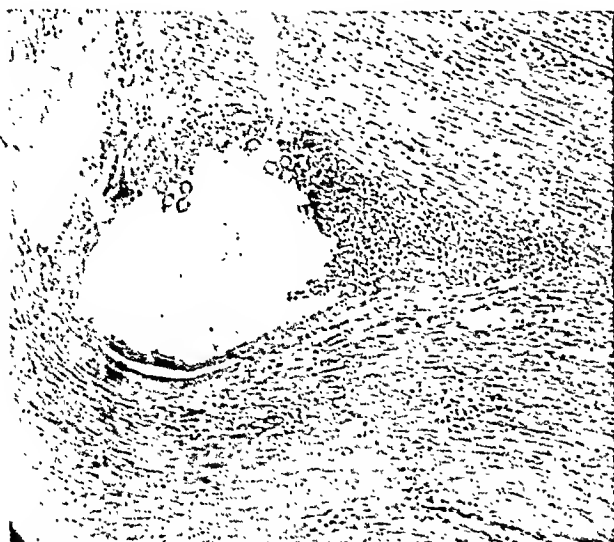


FIG. 7. Section through intestinal anastomosis, showing nylon suture in place with early polymorphonuclear leucocytic response, forty-eight hours postoperatively.



FIG. 8. Section through intestinal anastomosis, showing silk suture in place with early polymorphonuclear leucocytic response, forty-eight hours postoperatively.

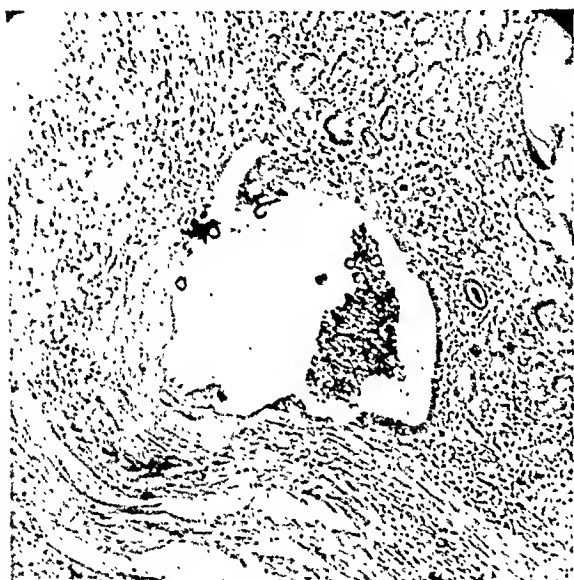


FIG. 9. Section through intestinal anastomosis showing nylon suture in place with subsiding acute cellular response and beginning round cell infiltrate, ninety-six hours postoperatively.

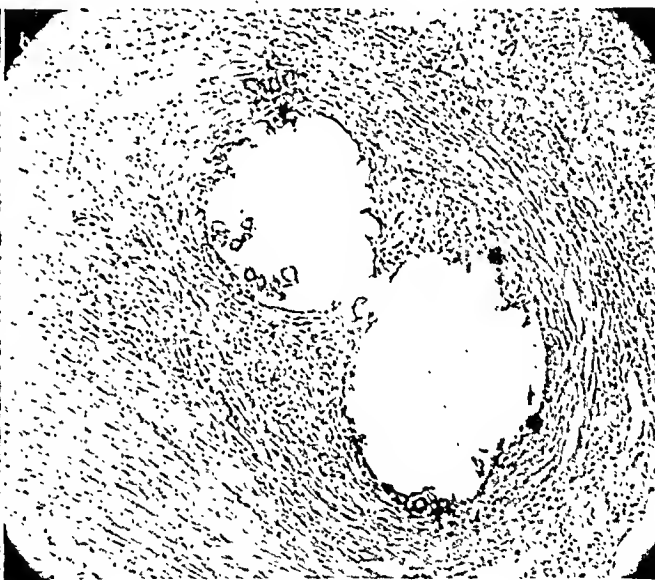


FIG. 10. Section through intestinal anastomosis showing nylon suture in place with typical foreign body reaction in later stage with foreign body giant cell formation and early encapsulation of suture by fibrous connective tissue, nine days postoperatively.

intervals show a similar reaction. There is no discernible qualitative or quantitative difference in the degree of reaction to either of the materials used. (Figs. 7, 8, and 9.) The latter specimens, namely, 9 days and 30 days, show changes characteristic of foreign body reaction in its later stages. There is replacement of the polymorphonuclear cells by round cells and plasma cells. The oldest specimens show beginning giant cell formation, with an attempt at

encapsulation of the suture by fibroblastic tissue reaction. (Fig. 10.) In these latter specimens as well, there is no discernible qualitative or quantitative differences between the reactions to silk and to nylon."

Conclusions. On the basis of this experiment, one may conclude that: (1) Nylon may be used as a substitute for silk or catgut in gastrointestinal anastomoses; and (2) nylon produces approximately the same degree of tissue reaction as does silk.

COMMENTS

Why substitute nylon for silk? Assuming that both are readily available and the costs of these materials are comparable, it was decided to determine whether there are any practical advantages of nylon over silk. The following physical properties of both these materials were then studied and compared: (1) surface smoothness, (2) tensile strength, and (3) elasticity, or degree of elongation.

Surface Smoothness. Microscopic examinations were made of both silk and nylon sutures. These revealed silk to have minute hair-like projections extending from its surface, whereas nylon was perfectly smooth.

Tensile Strength. This was determined by suspending the material to be tested between two jaws which were then pulled apart at the rate of 12 inches per minute. The tensile strength (breaking load) was read at the point of rupture of the material. Silk and nylon of various diameters were tested in the above manner, with the following results:

Suture No.	Diameter (inches)	Tensile strength (pounds)		Difference Per Cent
		Silk	Nylon	
C	0.006	1.23	1.65	34
2	0.014	6.90	6.22	10
5	0.023	15.98	16.65	4
6	0.028	19.20	24.90	29
8	0.033	27.80	31.83	14

Note that No. 2 silk had a greater tensile strength, but in all the other diameters nylon was the stronger.

Elasticity or Degree of Elongation. Probably more important than tensile strength is the elasticity, or degree of elongation, of a suture before it breaks. Assuming a suture has a tensile strength of 10 pounds, it will then break when this pull is exerted upon it; however, before breaking, it will stretch to its end point of elongation. In tying a knot,

the surgeon exerts a certain pull in tightening it. If the pull is greater than the tensile strength of the suture, the suture will break only, however, after being fully elongated. Thus, the elongation of a suture acts as a safety factor in preventing it from breaking. The greater the degree of elongation, the less the likelihood of the suture breaking. Elongation tests were performed to compare silk and nylon. The degree of elongation before breaking was determined. These tests were performed in a manner similar to that used in determining the tensile strength with the following results:

Suture No.	Diameter (inches)	Elongation (Elasticity)		Difference Per Cent
		Silk Per Cent	Nylon Per Cent	
C	0.006	25	10	30
2	0.014	15	10	27
5	0.023	16.5	23.5	42
6	0.028	23.75	30.0	22
8	0.033	24.2	27.45	13

Note that except for suture size No. C, nylon shows greater elasticity than silk in all of the sizes tested.

CONCLUSIONS

1. Nylon may be used with safety as a substitute for silk in gastrointestinal anastomoses.

2. Nylon produces approximately the same degree of tissue reaction as does silk in intestinal anastomoses.

3. Nylon has a smoother surface than silk.

4. Nylon has greater tensile strength and greater elasticity than silk in most thicknesses.*

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*The tests for tensile strength and elongation were performed by the United States Testing Co., Inc.

MANAGEMENT OF SHARP POINTED FOREIGN BODIES IN THE GASTROINTESTINAL TRACT*

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THE history of an individual having swallowed one or more sharp-pointed foreign bodies and the portrayal of these foreign bodies by x-ray examination usually bring some consternation to the attending physician or surgeon. As a rule those who have had the greatest experience in the management of such cases advocate careful observation and non-surgical treatment while those with only an isolated experience tend to favor surgical interference. There is no doubt that a sharp-pointed foreign body, and especially such complicated structures as an open safety pin, is a potential hazard for bowel perforation. An experience in which twelve young adults in a period of six weeks swallowed foreign bodies in an attempt to shirk their strenuous duties in a disciplinary training center seems worthy of relating. To have hospitalized these individuals and performed abdominal operations with a short or prolonged period of convalescence would only have been acceding to their wishes as it would have given them some respite from their strenuous assignment.

There are certain inherent dangers from a sharp-pointed foreign body passing along the gastrointestinal tube and maneuvering its way through the narrow passageways of the pylorus, duodenojejunal junction, ileocecal valve, colon flexures and sigmoid areas; and some anxiety is experienced by the attending surgeon who realizes that simple gastrotomy, ileotomy or colotomy with modern surgical technic carries very few dangers. In private practice, the expense of hospitalization and operation is an economic factor; but in the management of men from disciplinary training centers in the military

service or penal institutions of civilian life, it is desirable that such individuals do not escape arduous tasks or confinement for the special comforts of hospitalization by their overt acts. If escape for several individuals is accomplished, such a practice may assume epidemic form and therefore conservative management without hospitalization is most desirable.

The mechanism of sharp-pointed instruments passing through the velvety mucosal-lined gastrointestinal tube without penetrating and perforating the tubal wall is based on the factor of bowel wall trigger reaction, resulting in a firm contraction of the muscular wall which rejects the foreign body in most instances, provided no firm solid wall is backing up the other end of the sharp object. Rarely are the intestinal contents sufficiently firm to prevent backward dislodgment as the stimulated segment contracts, and the firm contracting wall makes it more difficult for the point to pierce the intestine. Again, if the point of the foreign body escapes contact with the wall and is directed into the lumen, the advancing ring of inhibition permits easy progress along the intestinal tract. In our experience, sharp-pointed objects always made slower progress traversing the intestinal canal, which is probably based on the premise that when the point contacts the intestinal wall and sets up repeated contraction rings, retardation in passage is the result. Ordinary sewing needles, with both ends quite sharp, were slower in passage than the larger, closed safety pin. The larger single pointed nail passed more rapidly than the sewing needle but slower than the closed safety

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FIG. 1. Open safety pin in lower sigmoid, passed without incident.



FIG. 2. Open safety pin in descending colon, passed without incident.

pin. Naturally, other factors do enter into the rapidity of travel, such as the thickness or length of the object and individual intestinal activity. Our observations and data show that after the foreign body travels beyond the splenic flexure, its passage through the descending colon and sigmoid is rather rapid. The fecal consistency as well as gravity may play a part in this progress. The exit of these sharp pointed bodies through the anal canal is most remarkable as no patient in this series complained of annoying distress as the object was being expelled. Following are individual case reports and remarks.

CASE REPORT

CASE I. D. S. T. In this first case observed by us, the soldier prisoner claimed that he had accidentally swallowed a straight sewing needle while repairing his clothing. He was seen about twenty-four hours following this incident and x-rays revealed a sewing needle in the small intestine. He was kept in the hospital about fifteen days before x-rays proved the complete passage and exit of the needle.

CASE II. N. N. This patient arrived a few days before the first man was discharged from the hospital. He might be considered a veteran at deliberately swallowing foreign bodies as he

had had a previous experience elsewhere five months before. The knowledge that his colleague was receiving satisfactory hospitalization at a hospital temporarily assigned to receive patients from the center probably encouraged him in his second offense. At his first experience he had been operated upon and a safety pin was removed from his stomach. This soldier arrived at our hospital about twenty-four hours after swallowing another safety pin. X-rays revealed an open safety pin in the jejunum and because of the pain of which he complained and the apparent abdominal wall rigidity, operation seemed advisable. Upon opening the abdomen it was found that the point of the pin had penetrated the intestinal wall and was just beneath the serosal layer. An attempt to close the pin or manipulate it along the jejunum gave one the impression that it was snagged in the wall of the jejunum. An attempt at backward displacement resulted in a twisting or turning of the pin and the point appeared through the serosa of the intestine. The jejunal wall was then incised and the safety pin removed without further incident. Although this was only the second case in our series, the repetition of this individual's attempt made us alert to the possibility of a deliberate act and he was transferred back to the stockade in about one week.

CASE III. A. R. B. This patient had been x-rayed at another hospital two months previously for having swallowed a nail. He claimed



FIG. 3. Open safety pin on right side and a closed safety pin on left side. The closed safety pin appeared to make much more rapid progress.

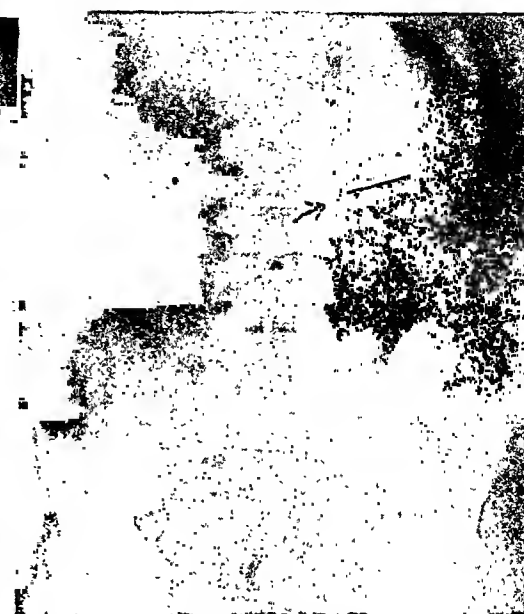


FIG. 4. A ten-penny nail and portion of a safety razor blade in the transverse colon. No difficulty was experienced.

that he saw the nail in the picture and that he was dismissed from the hospital in a few days without operation. He was x-rayed at our hospital because of the history of this previously swallowed foreign body and the complaint of abdominal distress. There was no evidence of a remaining nail. About ten days later he reentered our hospital, stating he had accidentally swallowed a safety pin. X-ray revealed an open safety pin. Because of continued distress (probably not present), he was operated upon and an open safety pin was removed from the cecum. Attempts to close the pin within the lumen of the colon were unsuccessful because of its very strong spring action. This third case in about three weeks substantiated our impression that these acts were deliberate and that there would be other cases in the future.

CASE IV. W. T. B. Two days after the admission of Case III, another soldier from the same stockade was admitted to the hospital, claiming that he had accidentally swallowed two needles while sewing. X-ray revealed two needles, one in the small intestine and one in the large intestine. The following day the x-ray study was repeated and only one needle remained, it now being in the rectum. The patient was immediately returned to the stockade without further incident.

CASE V. F. P. B. On the same day that Case IV was admitted, another soldier prisoner entered the hospital claiming that he had accidentally swallowed a staple six months previously. Unfortunately, his intelligence level was

so low that he had forgotten he had been in this same hospital one week before because of a backache and that anteroposterior and lateral films of the spine had been taken. These x-rays revealed no foreign body. X-rays taken on his second admission to the hospital revealed a rather large staple in the sigmoid. He was returned to the stockade without operation. Two days later an x-ray revealed no evidence of the staple. There was no doubt that he had prevaricated regarding the time when he swallowed the staple.

CASE VI. V. S. On the following day, another soldier was admitted from the stockade, claiming that on the previous day he had accidentally swallowed two safety pins. X-ray revealed one open safety pin near the hepatic flexure and a closed pin in the region of the descending colon. On the following day, x-ray study revealed that both pins had been expelled from the colon.

CASE VII. L. A. R. The same day that Case VI was admitted, this soldier was brought to the hospital with the story that he had swallowed a safety pin two days previously. X-ray revealed a closed safety pin in the rectum and he was promptly returned to the stockade.

CASE VIII. J. H. Several days later, another soldier was admitted from the stockade. X-ray revealed an open safety pin in the transverse colon and a closed safety pin in the sigmoid. The closed pin passed the next day but the open pin was somewhat slower in its journey through the sigmoid. Four days later it had been expelled without incident.



FIG. 5. A rather large staple descending through the sigmoid; passed without incident.



FIG. 6. A coil of barbed wire which traversed the intestinal tract.

CASE IX. J. D. Several days later this patient was admitted from the same disciplinary training center. He was x-rayed and a nail, a piece of twisted wire and portions of a razor blade were identified in the intestinal tract. Their progress was followed and five days later they were no longer seen on the x-ray films. He was told that he would be discharged that evening. Then he proceeded to swallow four straight pins which he had concealed. He was discharged in spite of this act. Two days later he was returned to the hospital for x-ray study and the film revealed that he had added a closed safety pin to the collection. All of these were passed without further hospitalization or incident.

CASE X. N. J. The following day, another soldier was brought into the hospital stating that he had swallowed a number of pieces of glass. This was authenticated by several other prisoners. There was nothing to be seen on the x-ray film and he was returned to the disciplinary training center without incident.

CASE XI. F. G. This prisoner claimed that he had swallowed a nail five days previously. He was checked by x-ray and the films were negative for a foreign body. He regretted that he had swallowed it and feared reporting the matter but his greater fear of the consequences forced him finally to seek medical advice.

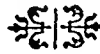
CASE XII. G. P. This prisoner soldier from the same disciplinary training center was x-rayed on the day he stated that he had swallowed a piece of barbed wire. The wire

was visible on the film but the patient was returned to the stockade. Three days later he swallowed a staple and two pieces of wire. By this time we had initiated the plan of having fellow prisoners guilty of the same act search their own stools or the other prisoners' stools for the foreign bodies. All of these foreign bodies were recovered from the stool in this case. Soon after this plan of stool searching was initiated, the epidemic came to an end.

Foreign bodies reach the gastrointestinal tract as a result of accidental or intentional means. Those classified as intentional occur in individuals who are side show freaks, are in an abnormal mental state, have suicidal tendencies, or are escapees, prisoners of various types desiring to escape punishment or work by creating a need for hospitalization and operation. In individuals who have swallowed foreign bodies, whether children or adults, alarm is caused by the story or history rather than symptoms. In two of these twelve cases, operation seemed indicated and was successfully performed. However, after our six weeks' experience with this group of individuals and review of the cases, we are inclined to believe that in one of these cases—the second case—we were misled by the patient's shrewdness in establishing a picture which simulated early perforation.

The usual treatment for sharp-pointed bodies which have been swallowed and have passed into the stomach or intestines is watchful waiting with careful observation and repeated fluoroscopic or x-ray examination. Only occasionally will operation be indicated. Bowel penetration or perforation evidenced by abdominal tenderness, muscle rigidity, changes in pulse, temperature and blood count would be an indication for abdominal exploration. If the sharp-pointed foreign body remains stationary for over twenty-four hours after leaving the stomach, very detailed observation of the patient is indicated. If it remains stationary beyond forty-eight hours, one should seriously consider

that the sharp point has engaged in the intestinal wall. Laparotomy should then be carried out and an attempt made to release the foreign body. There seems to be no need for special diet during the period of observation, although mineral oil in small amounts several times a day may seem indicated to prevent obstipation in the distal half of the colon. Surgery should not be instituted on the history alone but only on appearance of threatening signs and symptoms of perforation, or when there is more than a twenty-four to forty-eight hour delay in the passage of the object at any point along the gastrointestinal tract.



Correction: In an article by Dr. Harris and Dr. Feigen published in our August, 1946 issue, the authors wish to draw attention to an error they made on page 278. The sentence directly under the illustration in the second column should have read: "There is *some* question, however, as to whether every lymphocytoma which appears to be invasive and to show mitotic figures is clinically equally malignant."

WHY HERNIAS RECUR

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THE surgeon's primary concern while operating for a hernia, in spite of any technical refinements, is whether there will be a recurrence. It is a dogmatic soul indeed who, after operating for a hernia, can reply in the negative. The surgeon who can devise technics which are proof against any or all varieties of recurrence is well nigh worthy of the Nobel Prize. There are causative factors which are largely beyond his control and sometimes beyond his virtuosity as a surgeon.

In the latest literature the statistical average of primary recurrences varies from 0 to 20 per cent. With the secondary variety the average is even higher. Indirect inguinal hernias which occur in early life are not as commonly recurrent as the direct variety or saddle bag (pantaloon) hernias which are frequent in the older age group in which we find poor muscular and aponeurotic tissues.

An epigrammatist once remarked that nothing is so constant as change. This is especially true of the pendulum of opinion regarding recurrences in hernial surgery—the incidence, causes, prophylactic and reparative measures. It is well known, for example, that there is wide divergence of view even among prominent surgeons regarding the architectonics and myodynamics of the lower abdominal, inguinal and femoral areas.

One of the problems which plagued ancient anatomists and surgeons was Nature's apparently faulty "architecture" at and including the abdominal or deep inguinal ring. In our own day many anatomists and surgeons are equally puzzled regarding the myodynamics of the deep inguinal ring and seek an answer to the questions: "Is the mechanism of the ring a shutter or a

valve?" There are renowned proponents of each view. Manifestly, the correct answer to the question has a bearing on the success or failure of a technic utilized in a specific operation for indirect inguinal hernia.

THE OLD VIEW

The abdominal muscles prevent undue bulging of the abdomen, but they do not hinder the escape of the abdominal contents in the form of a hernial protrusion. The transversalis fascia, as a rule, is strong enough to retain the viscera within the abdomen. In other words, the fascias and aponeuroses and not the musculature prevent hernia formation.

The hiatus in the transversalis fascia lateral to the inferior epigastric vessels is covered by the internal oblique and transversus abdominis muscle. Nevertheless, this site is the point of exit of the commonest variety of inguinal hernia,—the indirect or oblique inguinal.

On the assumption that this theory is correct, one may reason that to cure the hernia it is only necessary to close the hole in the transversalis fascia. However, in the majority of hernias this is impossible because of the contiguity of the inferior epigastric vessels. Radical cure of this common form of inguinal hernia is, therefore, anatomically impossible because of the futility of attempting to close the defect in the transversalis fascia. The surgeon endeavors to overcome this impasse by improvising an obturator of fascial, aponeurotic and muscular structures. The interposition of an unyielding fibrotic membrane is an inadequate substitute for a live contracting myodynamic shutter. It is advantageous instead to utilize the aponeurotic extensions of the conjoined tendon

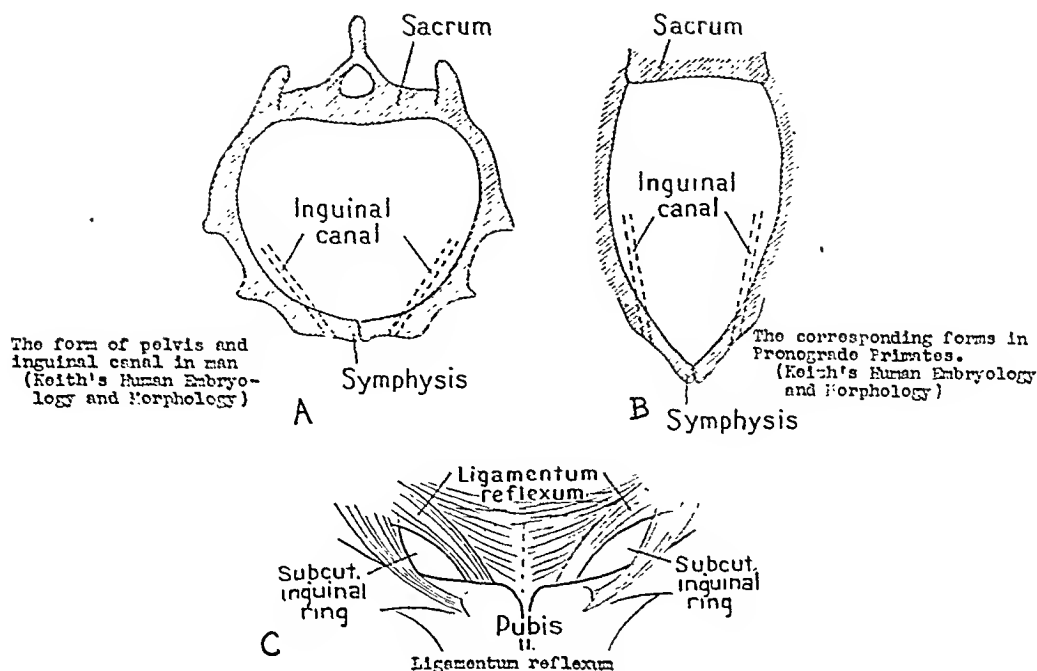


FIG. 1. Man's susceptibility to hernia, caused by the orthograde posture, is overcome by the visceral support and the obliquity of the inguinal canals.

and in large, direct hernias, where the deficiency is extensive, a fascia lata transplant.

The two important theories concerning the deep inguinal ring may be briefly reviewed here, as follows:

In 1923, Sir Arthur Keith, in his description of the mechanics of the "inguinal shutter," described the conjoined muscle as a "shutter" rather than a sphincter, with a mechanism similar to that which closes the eyelids. The inguinal ligament, the counterpart of the lower lid, remains stationary. Any weakness of this neuromuscular function, reflex in character, predisposes to hernia. In man's evolution the groin is weakened by the adaptations the pelvis had to undergo. In 1929, W. W. MacGregor stated his agreement with this view. (Fig. 1.)

THE MODERN VIEW

Keith, as we have seen, viewed the deep inguinal ring as a fixed opening. The modern view, however, maintained especially by W. J. Lytle of Sheffield (England), is that the ring is mobile—an active mechanism of closure which under stress moves *upward* and *outward* under cover of the internal oblique and transverse muscle.

The deep inguinal ring, when viewed on

the posterior wall of the inguinal canal, is consequently a pivot around which the transversalis fascia is arranged. The U-shaped ring, composed of fibrous strands (incomplete superiorly) is placed obliquely and sometimes almost vertically midway between the anterior superior spine and the symphysis pubis. It has a thick and therefore strong inner margin and an angle below lies subjacent to the edge of the transversus muscle to allow free passage of the spermatic cord. The fibrous strands surrounding the ring vary in length and their ends are firmly anchored as "slings" to the posterior aspect of the transversus muscle. The prominent margins of the ring extend backward at an angle below the spermatic cord. Ring mobility, Lytle maintains, is easily demonstrated under a local anesthetic. If the edges are held under tension and the patient is requested to cough, the ring can be observed and felt to move *upward* and *laterally behind the internal oblique and transversus muscles*. On release of tension, movement of the ring on coughing is slight or absent. (Figs. 2 and 3.)

It is, therefore, obvious, Lytle argues, that the stretch reflex (closure mechanism) is activated in protecting the inguinal

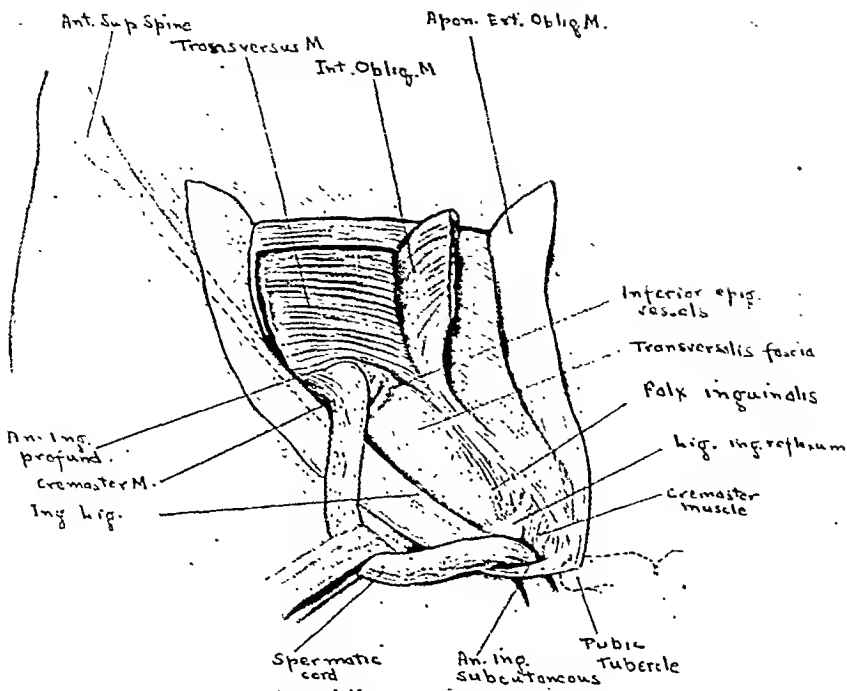


FIG. 2. The inguinal canal in male.

canal. The action consequently is that of a *sliding valve* and not of a sphincter or a shutter because it is arranged to avoid extreme pressure on the spermatic cord which both these mechanisms would tend to exert. It is also held that the amplitude of the medial pillar of the ring is greater than that of the outer. The first is fixed to the medial part of the transversus muscle and to its aponeurosis where the greatest range of muscular movement occurs while the outer pillar is anchored to the muscle fibers near their origin, where the muscle moves only slightly on contraction. The margins of the ring project and as the cord enters laterally and below the medial margin overlaps the opening and thus acts as a lid or valve protecting it against continuous but changing intra-abdominal pressure.

Varieties of Recurrence. The varieties of recurrence are: (1) Direct hernia, which is the most frequent (Fig. 4); (2) indirect hernia (Fig. 5); (3) saddle-bag or pantaloons hernia (Fig. 6); (4) Spigelian hernia, along semilunar line (Fig. 7); and (5) bladder hernia. (Fig. 8.)

ETIOLOGY OF HERNIA RECURRENCES

The causes, anatomic, congenital and technical, that conduce to recurrences in hernia surgery may now be considered.

Briefly stated, the main causes of recurrences are inefficient surgical technics and incorrect after-treatments. The basis of all surgical measures should be high ligation of the sac in indirect inguinal hernia, and careful repair of the attenuated transversalis fascia in the direct variety. Not infrequently indirect and direct inguinal hernia are concurrent and one is repaired and the other overlooked. Such an omission is due to an incomplete knowledge of the anatomy and myodynamics of the lower abdominal wall. The result is a persistence of the original anatomic defect or defects, congenital or acquired.

SURGICAL CAUSES

Pre-surgical. The pre-surgical causes are: (1) Incorrect diagnosis; (2) poor planning. This involves improper choice of operation as shown, for example, in the use of the Bassini operation or one of its

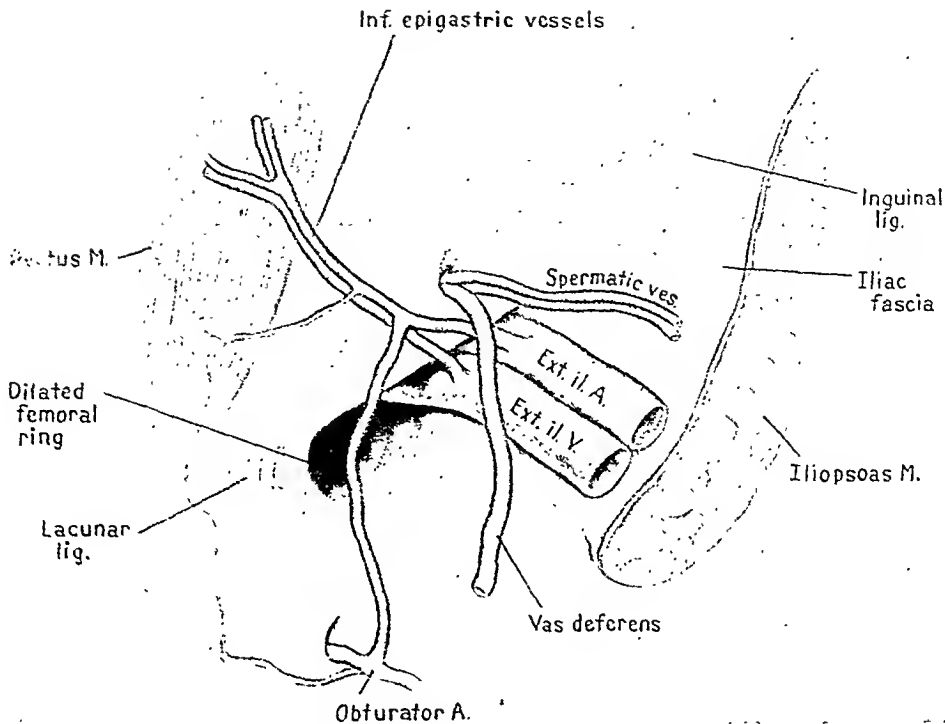


FIG. 3. Vessels, muscles and ligaments of the inguinal region seen from within.

modifications, in infants, older children and young adults. (3) Unsuitable selection of patient. The patient should be carefully examined to determine the presence or absence of such conditions as excessive obesity, asthma, acute or chronic bronchitis, myocarditis, active syphilis, hemophilia and other blood diseases. There must be proper pre-surgical preparation, such as care of the heart, diminution of abdominal distention and measures leading to reduction in weight.

Surgical. (1) Anesthesia. The kind of anesthesia used is of importance in the prevention of recurrence. The patient must be completely relaxed during a hernial operation. This permits tensionless apposition of tissues. Spinal anesthesia is therefore the method of choice. (Huston reported only 0.8 per cent recurrences where this variety of anesthesia was used.) There are few post-surgical complications,—vomiting, distention, and undue body strain, for example, in the use of spinal anesthesia. (2) Wrong choice of operation, (3) improperly placed incision, (4) incomplete asepsis, (5) poor hemostasis, and (6) other

technical errors. Prior to the ligation of the sac the surgeon should explore the nether surface of the inguinal floor. Hidden defects will thus be discovered as well as the laxity or strength of available tissues in the contemplated reconstruction of the wall. At the primary operation, weakness, dehiscence or absence of fascia transversalis may not have been noted as well as the presence of a large femoral ring or underdeveloped inguinal ligament. A correct interpretation and evaluation of the structural defects present is therefore of transcendent importance, as well as a proper repair at the time of reconstruction. The utilization of fascia strips, or pedicle graft, where the fascia transversalis is *not* structurally weak or underdeveloped, is an incorrect surgical procedure. Its routine use in various recurrent hernias is unjustified.

(7) Failure to detect or correct "sliding" hernia,—to discover the direct component of the protrusion. This is especially true after the age of forty. Surgeons sometimes fail to carry the peritoneal dissection high enough to separate the direct sac from the bladder wall and undersurface of the

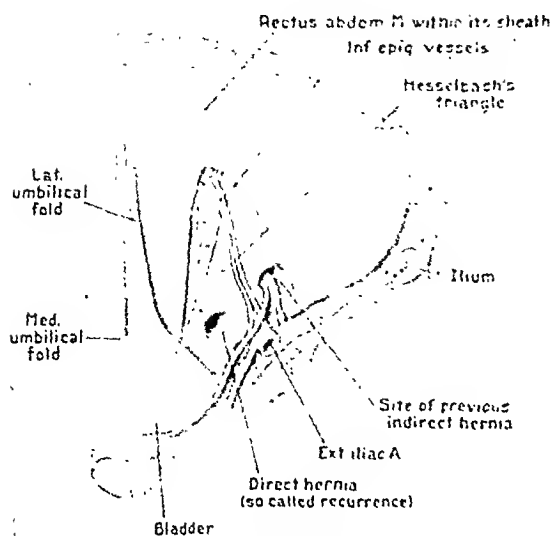


FIG. 7. Spigelian hernia.

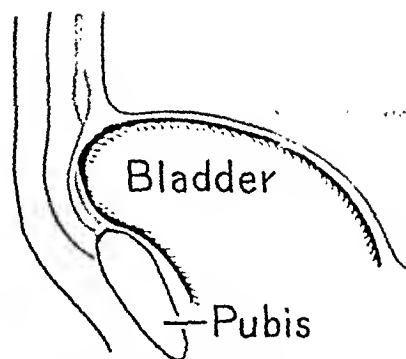


FIG. 8. Bladder hernia.

inguinal floor. (8) Failure to narrow the deep abdominal ring; (9) failure to repair defects in the inguinal triangle; (10) failure to transplant spermatic cord in older age group; (11) failure to remove spermatic cord in elderly patients. Removal of the spermatic cord, in conjunction with hernioplasty, is definitely indicated in the large hernias of persons over sixty years of age; (12) division of nerves. This leads to the destruction and atrophy of the affected parts of the lower abdominal wall; (13) failure to use fascial transplant where muscles and aponeuroses are deficient.

(14) Improper suture material. Most authorities condemn the use of catgut in herniorrhaphy. Longacre, for instance, wrote that with indirect hernia the "catgut" recurrence rate is 12.5 per cent and with silk 3.4 per cent and in direct hernia 13.6 per cent as compared with 4.49 per cent. The use of absorbable or non-absorbable material, in my experience, does not influence the final results in hernioplasty. There is, however, an increasing tendency to use non-absorbable suture material. Fascial sutures of the transplanted variety, e.g., autogenous material, yield somewhat better results in difficult hernias than plain catgut or silk. The utilization of the pedicle flap (such as fascia lata transplant with

conservation of its nerve and blood supply) has a distinct advantage over fascial sutures.

(15) Unwise use of drainage tube and its improper placement and prolonged retention. In the presence of sepsis the proteolytic action of the pus digests adjacent tissues, converting it into granulation tissue and as a result the wound is liable to stretch or burst during an increase of intra-abdominal pressure from any cause. (16) Bilateral operations in people over forty-five years of age in whom there is a large hernia or weakness of muscular and aponeurotic structures.

POST-SURGICAL CAUSES OF RECURRENCES

Weight bearing should be postponed until the scar tissue, on which the union of the deep layers depends, has consolidated. This requires a minimum of seven days in bed.

Immediately after the operation the patient should be warned to avoid coughing as far as possible, not to strain at bowel movements and not to attempt to raise himself in bed.

Omission of the warning regarding strain or hard work for three months after the operation is another cause. This applies to active physical occupations, especially in persons over forty-five years of age.

Patients past forty-five years of age with large hernias and poor muscles and aponeuroses and with extreme weakness in the inguinal triangle should not be permitted to return to laborious work. The percent-

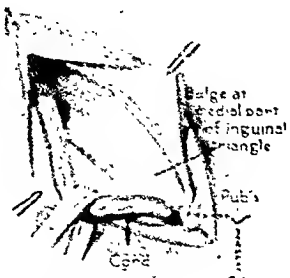


Fig. 4

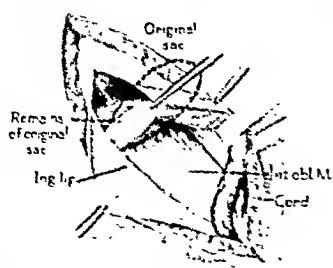
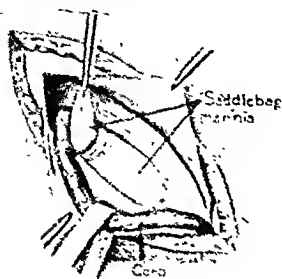


Fig. 5



Fig. 6a



6b

WYLLYS ANDREWS METHOD (MODIFIED)

CORD PLACED SUPERFICIAL TO EXTERNAL OBLIQUE.

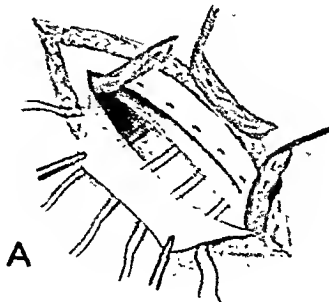


Fig. 11a

INADEQUACIES

- 1 Cannot be used in majority of hernias
- 2 Cannot be employed where tendo conjunctus is weak
- 3 Fascial reinforcement is superficial to defect

BASSINI METHOD

CORD PLACED SUBJACENT TO EXTERNAL OBLIQUE.

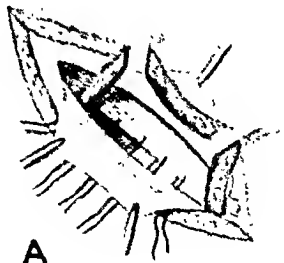
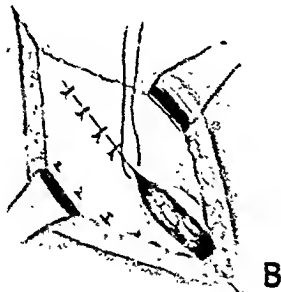


Fig. 10



B

INADEQUACIES

- 1 Strangulate internal oblique resulting in atrophic scar tissue
- 2 Muscle bundles offer no protection against pressure perpendicular to fibers
- 3 Places tendo conjunctus in abnormal position

AN ANATOMICAL PHYSIOLOGICAL HERNIAPLASTY

CORD PLACED SUPERFICIAL TO EXTERNAL OBLIQUE.

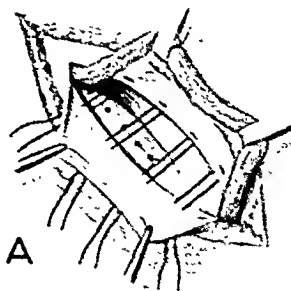
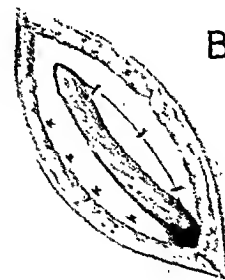


Fig. 11b



B

- 1 Approximates similar structures
- 2 Re-enforces weak transversalis fascia

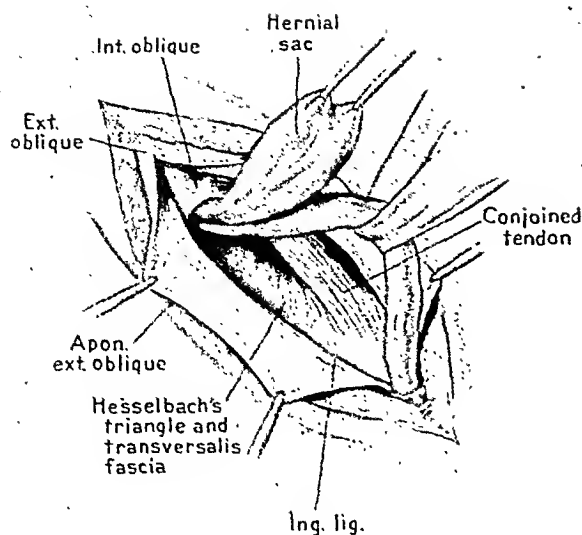


FIG. 9. Indirect inguinal hernia. Good musculo-aponeurotic structures; simple high sac ligation will effect a cure.

age of recurrences in this group is too large. They should be assigned to lighter occupations.

EVALUATION OF SURGICAL TECHNIQUES

Another perennial polemic subject relating to hernia recurrences concerns the

actually a basic factor in the recurrence of the hernias, especially in those of short duration, in which the deep ring is only slightly stretched. The musculature is unnecessarily injured, thus favoring a recurrence. It will be recalled that all the modifications of the Bassini operation utilize the suturing of the internal oblique and conjoined tendon to the dense inguinal ligament. (Fig. 10.)

Suture of the conjoined tendon to the inguinal ligament, one of the steps in a Bassini repair, is fallacious because there is often no weakness in the floor of the canal and muscle is not a perfect bastion, its function being largely that of motion. Furthermore, muscle anchorage results in atrophy from disuse and is weaker than before because of traumatic myofibrosis. Recurrences are thus induced by disordered myodynamics. It is known that; in the main, they do not occur through the posterior wall of the inguinal canal but through the abdominal inguinal ring. There is recurrence in the true meaning of the word. (The ring, unlike a parachute, functions best when closed).

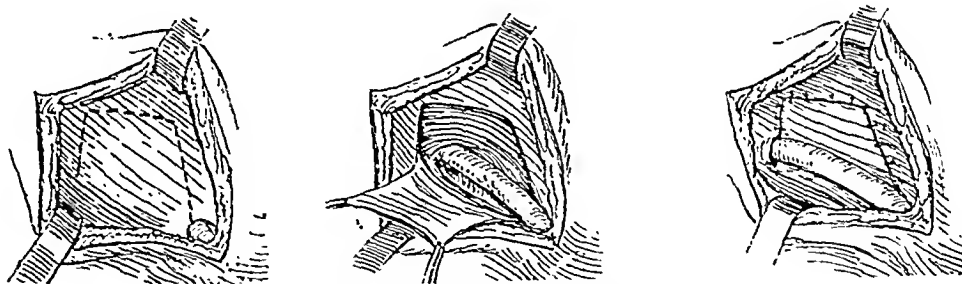


FIG. 12. A, B and C, steps in the Beach operation.⁶

adequacy or inadequacies of the various so-called standard operations for indirect inguinal hernia. In the younger age group, where there are, as a rule, good muscular, aponeurotic and fascial structures, a simple high sac ligation with excision of the redundant portion is all that is necessary for a complete cure. (Fig. 9.)

It is widely urged by surgeons that in the Bassini operation and its various modifications (Halsted, Ferguson, and others), certain steps are not only unnecessary, but

It is manifest, therefore, that the control of the inguinal area depends on the unimpeded action of its musculature and an operation which interferes with its normal mobility diminishes the strength of the lower abdominal wall and tends to induce, rather than prevent, recurrence. This is clearly shown by the cures in infants and children after mere ligation and excision of the hernial sac. The percentage of cures is better than the best results obtainable in adults. No buttressing is needed since the

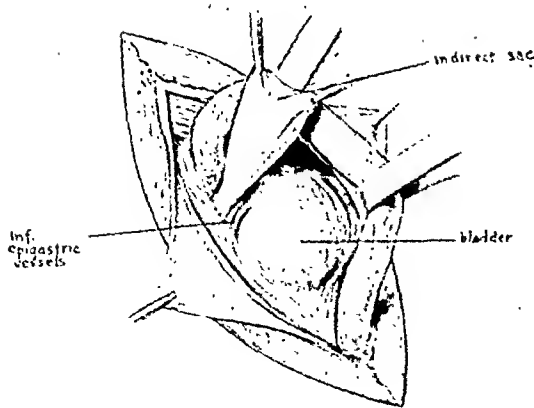


FIG. 13. Indirect inguinal hernia and hernia of bladder in inguinal triangle.

local myodynamics remain undisturbed and the muscular and aponeurotic structures have not been overstretched.

Anson and McVay found that the basic errors in the Bassini technics are due to a not uncommon misunderstanding of the surgical anatomy of the inguinal area. They maintained that the inguinal ligament is not the site of the insertion of the internal oblique and transversus muscles and is not anchored securely enough to withstand the pull of the abdominal muscles.

In patients operated on for recurrent inguinal hernia the ligament is displaced upward completely exposing the lower inguinal region. In some instances there is no vestige of the original ligament. Anson and McVay advocated utilization of the conveniently located superior pubic ligament, a dense fibrous structure on the antero-superior aspect of the pubic ramus.

In view of the aforesaid it is suggested that owing to the proved fatuity of the Bassini operation and some of its modifications it should be considered antiquated. For indirect inguinal hernia, in well developed persons, in whom the deep ring is not greatly enlarged, simple hernioplasty or herniorrhaphy with repair of the transversalis fascia deep to the muscles at the ring is deemed adequate. For large hernias, direct or indirect, primary or secondary, a modification of the Wyllys Andrew operation is most effective.

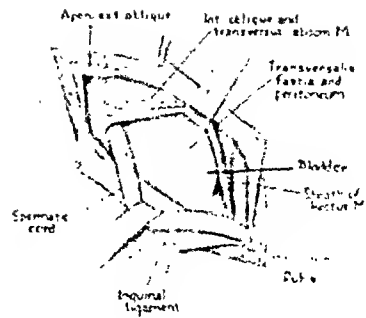


FIG. 14. Bladder protrusion in a direct inguinal hernia.

The method used by the author is clearly demonstrated in Figure 11. It will be seen that the cord is placed superficially, subjacent to the deep layer (Scarpa's) of the superficial fascia. The repair does not compromise the activity of the abdominal muscles.

Some reparative or restorative technic is necessary, one which, as already emphasized, interferes least with the musculature. The inferior margin of the transversus abdominis aponeurosis and attached transversalis fascia are sutured to the inguinal ligament from the pubic tubercle to the femoral vein by a series of interrupted silk or catgut sutures.

When an oblique inguinal hernia increases in size the deep ring and especially its lateral margin gradually stretches, weakening and lessening its mobility. Mere removal of the sac is inadequate because a dilated ring leaves a weak spot, and unless the ring is narrowed to normal size the sliding valve mechanism does not function adequately. A dilated ring may be the result of, and probably also a causal factor in, indirect inguinal hernia.

In order to circumvent the basic error in the Bassini and other operations in the repair of indirect inguinal hernia, W. W. Beach urges that his technic will avoid recurrences, one in which "all repair of the posterior wall of the inguinal canal is completely avoided and the canal itself suppressed."

In this operation a flap from the aponeurosis of the external oblique is utilized to replace the inguinal canal by an "in-



FIG. 15. Large direct right inguinal hernia. No evidence of an indirect hernia. The bladder constituted the entire hernia.

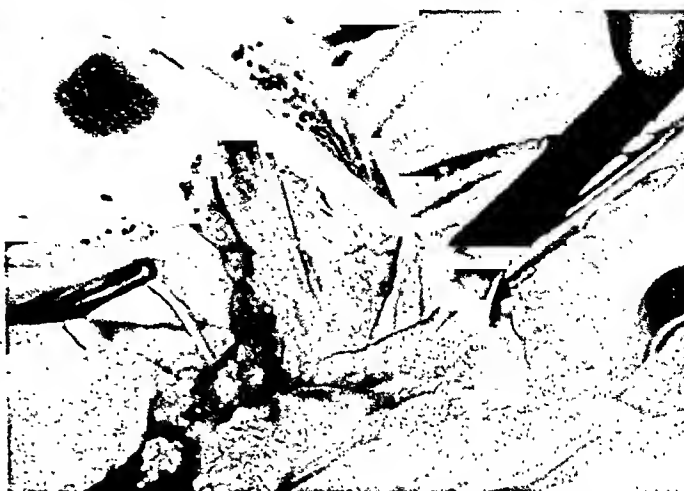


FIG. 16. Saddle-bag hernia, showing two sacs; the smaller one is the bladder.

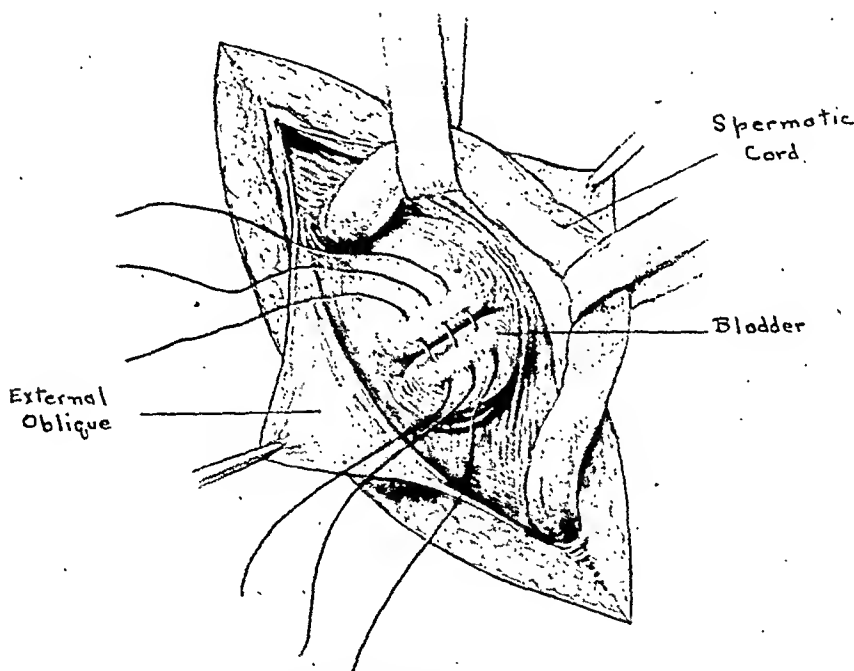


FIG. 17. Reducing redundancy in bladder wall. Former method of repairing bladder hernia.

guinal exit lateral to and above the center of the abdominal inguinal ring." He maintains that not only is the subcutaneous ring obliterated, but a gravitation obstacle is put in the way of a recurrence. (Fig. 12, A, B, and C.)

Fundamentally, the Beach procedure in uniting like tissue in a more complicated manner does not accomplish any more than a modified Wyllys Andrew operation.

Another operation designed to obviate

recurrences is that advocated by Mair, in which whole skin implants are inlaid, under extreme tension to protect the posterior wall of the inguinal canal and to narrow the deep inguinal ring. He believes this technic is superior to those utilizing fascial grafts.

The transplantation of a cutis graft inlay is highly valued by the proponent of the technic. However, dissimilar tissues are united and an inert protective membrane is utilized as a graft in which tissue of tensile

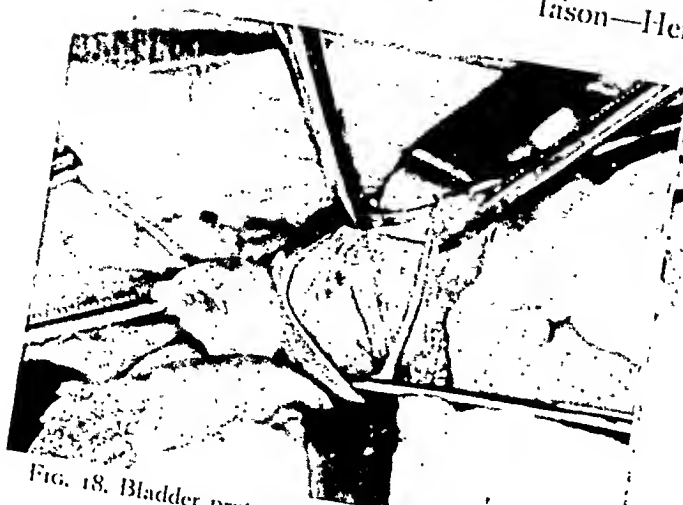


FIG. 18. Bladder protrusion has been resected, ready for closure; new method.

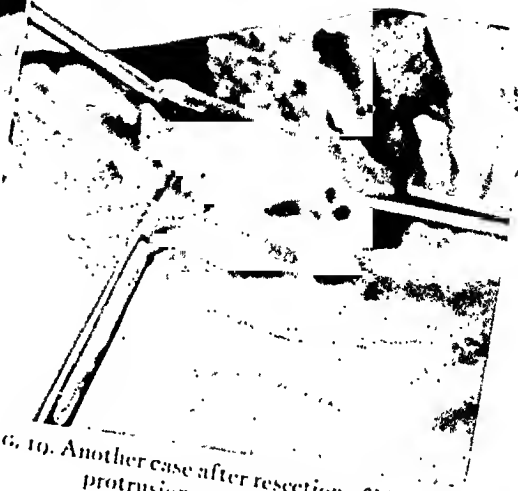


FIG. 19. Another case after resection of bladder protrusion; new method.

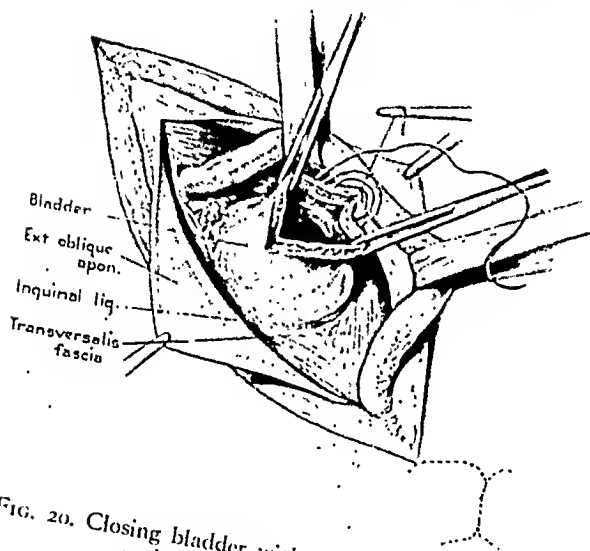


FIG. 20. Closing bladder with Connell suture after excision of herniated part.

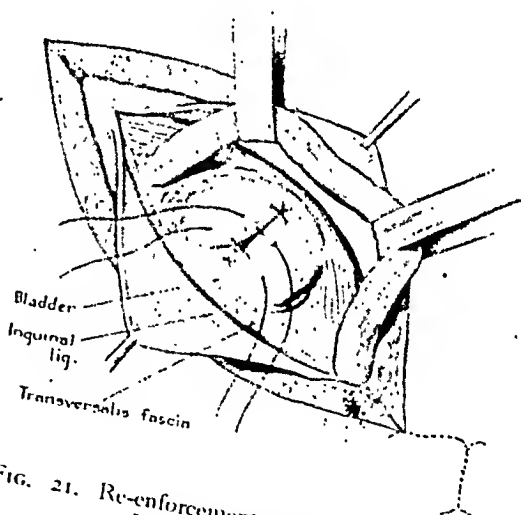


FIG. 21. Re-enforcement with interrupted Lembert sutures.

strength is required. The value of the technic, it seems to me, is still open to proof.

One of the most difficult varieties of hernia to repair is that in which the minor or major part of the content is the protruded bladder wall. It is either a complication or an integral part of an inguinal hernia. Statistical studies reveal an incidence of 1 to 3 per cent, but in my experience it is at least 15 per cent in persons over fifty years of age with inguinal hernias of moderate size.

In so-called recurrences after operations for inguinal hernia one must, therefore,

anticipate a return of an imperfectly repaired bladder protrusion. Failure on the basis of the surgeon to analyze the anatomic it, timidity in opening the bladder and dealing adequately with it, are the fundamental causes of recurrences.

There are three varieties of primary inguinal bladder hernia (Figs. 13, 14, 15 and 16): (1) As part of a direct inguinal hernia through the inguinal triangle, without evidence of an indirect inguinal sac. The base is sessile and covered by an attenuated transversalis fascia. (2) As a complication of an indirect inguinal hernia in which there

is a direct connection between the bladder protrusion and the indirect inguinal components. (3) As the medial part of a saddle-bag or pantaloons hernia in which the lateral bladder wall protrusion is part of the medial wall of an indirect hernial sac. Here again, the transversalis fascia is attenuated to an extreme degree. Occasionally the intraperitoneal portion of the bladder lies directly within the hernial sac.

During the surgical repair of this form of hernia it is well to be circumspect regarding: (1) An undue collection of adipose tissue contiguous and medial to the sac; (2) isolation of the sac; (3) dimensions of hernia; and (4) location (urinary bladder hernias ordinarily are found closer to the medial line than other varieties).

In the past it has been customary with most surgeons to repair the hernia in the accepted manner and to cover the bladder protrusion by reinforcing it with the overlying muscular and aponeurotic structures (Wyllis Andrew, Halsted or Bloodgood, technics). (Fig. 17.)

I usually eliminated the bladder redundancy by either a double purse-string inversion or by a double layer of interrupted Lembert sutures, and then followed the ordinary technic for a direct or indirect inguinal hernia. (Figs. 18 to 22.) However, there have been too many recurrences of bladder protrusion in all of the three varieties previously mentioned. I have, therefore, devised the following procedure which appears to be of high efficacy:

The repair of the bladder hernia is the same in the three varieties. In the second one, the small, indirect hernial sac must be removed first, prior to the repair of the bladder protrusion. In this sequence there is no danger of contamination because the bladder has not only been completely emptied by catheterization at least twenty-four hours before the surgical intervention, but irrigated several times with a weak antiseptic solution. The catheter is not removed until seventy-two hours after the operation. In the third variety, traction is made on the indirect component of the sac

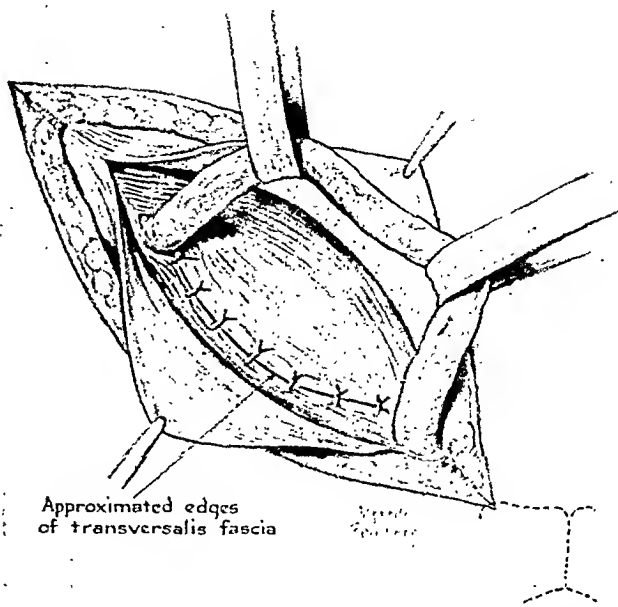


FIG. 22. Approximation of edges of transversalis fascia with interrupted sutures.

(as in the repair of all saddle-bag hernias). The bladder protrusion is partly displaced medially; the indirect hernial sac is opened so as to visualize the extent of encroachment on its wall and to avoid puncturing the bladder in the transfixion of the indirect hernial sac. The following technic is then used for the repair of the vesical hernia:

The base of the diverticular protrusion is caught by several Allis clamps and the redundant part excised. After thorough hemostasis, the edges of the stoma are inverted by means of a Connell stitch, which is reinforced with interrupted Lembert sutures, utilizing No. 0 chromic catgut on an atraumatic needle. The margins of the transversalis fascia are then approximated and sutured with interrupted strands of No. 0 chromic catgut. The hernial repair is then continued with the utilization of one of the technics commonly found acceptable in the repair of direct inguinal hernia.

Digital exploration of the bladder cavity may be carried out and closure is then accomplished after a change of gloves.

There have been no recurrences in my series of thirty-seven patients. There was one wound infection and no urinary extravasation in the surgical area.

Seelig and Chouke, after an investigation of the moot question of union of muscle

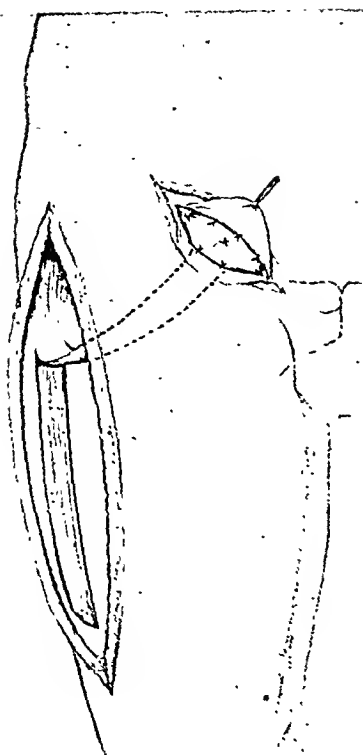


FIG. 23. Placement of fascia lata graft.

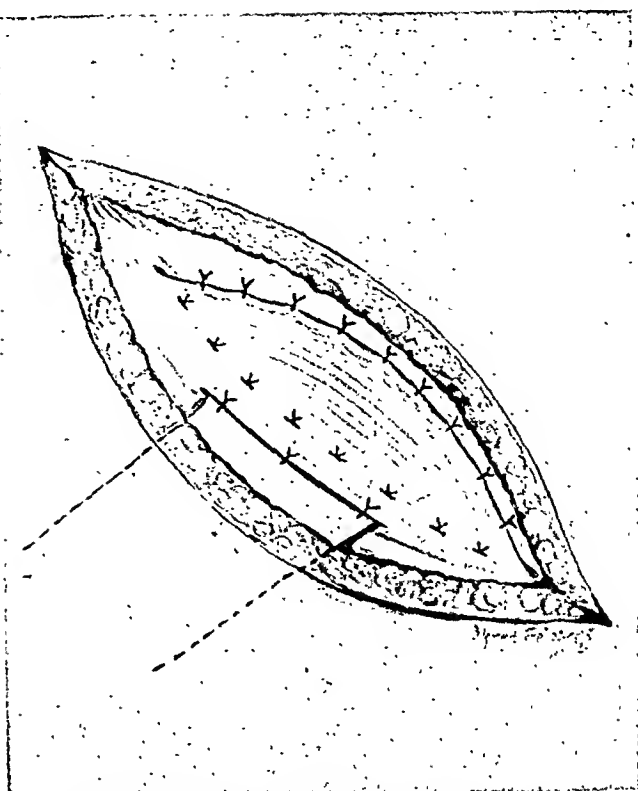


FIG. 24. Appearance of fascia lata graft in recipient area.

and fascia concluded that "normal muscle will not unite firmly with fascia and ligament. It is, therefore, a useless procedure to suture the abdominal muscles to the inguinal ligament in the hope of buttressing a weak or ruptured abdominal wall." When two living fascial planes are approximated there is complete and enduring union.

With extreme relaxation of the inguinal triangle consequent on the absence or inadequacy of the transversalis fascia, whether it be due to weakness, with loss of physiologic and anatomic functions of the abdominal wall as a bulwark, the utilization of pedicle flap fascia lata transplants has unparalleled values. It is a truism that all ameliorative efforts, medical or surgical, should be strictly individualized. The procedure has been adequately described as indicated in the references. (Figs. 23 and 24.)

The transplantation operation is justified on the following theoretic and practical grounds: (1) It is an attempt to produce better results by serving as a reinforcement for the inguinal triangle. (2) The inguinal

ligament and tendo conjunctus are not drawn together, thereby distorting their relationships. Their function capacity is preserved, truly a conservation of natural resources of the part. (3) The iliotibial band is the only accessible and mobilizable fascial musculature available. With an intact nerve and vascular supply, its elasticity, contractility and extensibility are retained. The myodynamics of the area remain undisturbed.

It is manifest, therefore, that the use of living fascia in the repair of certain varieties of large and complicated hernias is of transcendent value as compared to all other forms of suture material. The probability of recurrence is then diminished.

PREVENTION OF RECURRENCES

In order to prevent recurrences it is necessary to adhere to certain basic surgical principles; (1) Elimination of causes as far as possible; (2) reestablishment of natural physiologic and mechanical forces; (3) avoidance of technical errors, especially of

STUDY OF 3,000 CASES

Varieties	Sac	Transversalis Fascia	Secondary Protrusion	Repair	Closure
1st Degree....	Indirect	Normal	None	Sac ligation	Normal
2nd Degree....	Indirect	Weak	None	Sac ligation, plication of fascia	Modified Wyllys Andrew
3rd Degree...	Saddle-bag or pantaloons	Weak	Yes	Conversion into indirect sac or ligation of both sacs separately. Plication of fascia	Modified Wyllys Andrew, with or without fascia lata transplant
4th Degree...	Saddle-bag or pantaloons	Weak	Bladder diverticulation	Ligation of indirect sac. Bladder diverticulectomy. Plication of fascia	Modified Wyllys Andrew. Bladder diverticulectomy with or without fascia lata transplant

Note: In those beyond sixty years of age, either removal of cord or vasectomy in addition.

suture tension; and (4) selection of the proper surgical procedure.

CONCLUSIONS

1. Until comparatively recent years primitive concepts held sway concerning the etiology and physiological anatomy of hernia. Based on these concepts, surgical procedures were carried out which in our day seem to transcend the limits of human credulity, but which received the sanction of surgical custom.

2. With a profounder knowledge of the anatomy and physiology of hernia, investigators have attempted not only to classify the varieties of hernia, but also to devise a special procedure for each.

3. Recurrences, nevertheless, occur though less frequently.

4. A classification of recurrences is herewith presented in an attempt to clarify not only the causes of failure but also to form a basis for the choice of special operations.

5. A further study of the recurrences which is now being made reveals a progressive diminution in the incidence of failures.

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VASCULAR TRAUMA

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BECAUSE of the dramatic impact of massive hemorrhage, man's attention in all wars has been directed to the diagnosis and treatment of vascular trauma. In no preceding war, however, have the opportunities for study, observation, diagnosis and treatment been more feasible and extensive than in this past great battle of World War II.

This has been due to two basic facts: (1) greatly improved methods of combating shock, hemorrhage, and infection so that the wounded soldier lived to be treated definitively for his lesion in a hospital, and (2) the multiplicity of wounds in a single individual arising from the greatly improved missiles and death dealing implements that have been devised. We have observed numerous cases in which an individual soldier has had twenty to thirty varying sized perforating, penetrating and lacerating wounds, each of which is a potential source of vascular trauma. Elkins has noted as high as a hundred separate wounds in some of the men observed by him at the Vascular Trauma Center.

It is the aim of this paper to describe and give the general rules of treatment for the various types of arterial lesions which were observed in a General Hospital functioning for eighteen months close behind the combat zone. I am cognizant that this paper is presenting no new evidences, or disease or revolutionary methods of therapy. That has not been the object. It is the desire only to present in one paper a summation of the known and approved principles of diagnosis and treatment of vascular trauma.

It is believed that many patients passed through our hands in whom a diagnosis of vascular trauma was not made because, first, we received the patients shortly (two to five days) after the injury, and second, we rapidly disposed of them by evacuation

to the rear in seven to fourteen days after trauma. In this comparatively short period many lesions did not have sufficient time to manifest themselves either by clinical signs or symptoms, as frequently evidences of vascular injury are not encountered for several months following the initial trauma.

THE TOURNIQUET

The primary concern in the treatment of vascular injuries is the arrest of hemorrhage and the preservation of life. This control of major bleeding is often accomplished with the application of a tourniquet which, however, if one is to avoid further damage to the extremity, must be used intelligently and with understanding. The origin of the tourniquet has been lost in antiquity but the catastrophes that accrue from its improper use are still prevalent. To borrow and paraphrase a saying the tourniquet is used "too often, too tight and too long." It is agreed by all investigators that the ideal tourniquet is a pneumatic cuff allowing easy and ready control of pressure without disturbing the patient. However, on the field in war, or in an emergency in civilian life, where this type of apparatus is not handy, an Esmarch bandage or even rubber tubing placed over a cloth will suffice. The tourniquet should be applied as close to the wound as possible. A tourniquet applied below the elbow or knee is of no value as the interosseous arteries cannot be compressed by this means, and with occlusion of the vein and no slowing of arterial flow the end result will only be increased hemorrhage. Holman has suggested that any limb which has a tourniquet applied should be encased in chipped ice. By this procedure, the length of time the tourniquet applied can be left in place is increased to five to six hours, bacterial growth is inhibited, shock re-

duced and comfort increased. Allen has even suggested that by the time the patient arrives at the Evacuation Hospital the débridement of the wound could be done without further anesthesia, the ice having sufficiently chilled the tissues to allow operative procedures to be instituted.

The complications that follow misuse of the tourniquet are often disastrous and often more permanently disabling than would have been the loss of blood for which it was applied. Paralysis of the peripheral nerves is not uncommon, and though this is usually temporary and subsides in five to nine months, it may be permanent. Spiegel and Levin report three such cases in which operative intervention showed necrosis, neuromas, adhesions and intraneural scarring of the involved nerves. We observed a case of a British flier who had complete loss of motor and sensory nerve impulses 2 inches below the knee. No lesion could be found which would explain this complete nerve blockage, but on questioning we learned that a tourniquet had been applied tightly for a long period of time to arrest a slight amount of bleeding.

It is believed that most bleeding, even profuse hemorrhage from a major vessel, can be satisfactorily controlled by elevation of the extremity and the application of steady, firm pressure by the use of an elastic bandage, wrapped over several thicknesses of gauze, or still more satisfactorily by manual pressure. This latter method was well illustrated in a patient with a compound comminuted fracture of the femur (upper one-fourth) who two weeks after injury suddenly developed severe secondary hemorrhage. The patient was in a spica and a tourniquet could not be applied. Bleeding was controlled by the application of firm, constant, manual pressure over the bleeding site. If technically possible, the ideal method of controlling bleeding is, of course, the application of hemostatic clamps directly to the offending vessel.

The point to be stressed is that prolonged

application of a tight constricting band to control bleeding is not necessary. Do not let this be a case in which the cure is worse than the disease.

ARTERIAL SPASM

This syndrome first described by Leriche is not dependent on actual trauma to the vessel itself for its production. A missile passing close to the artery and traumatizing the surrounding tissue would be sufficient cause to institute spasm of the wall. This condition is produced by reflex vasoconstrictor impulses of the sympathetic nerves, and may in extent be local, segmental, involve the entire length of the vessel or even cause spasm of all the collateral branches of the limb. It is most frequently transitory, but may persist for a sufficient length of time to cause the extremity to become cold, pulseless and paralyzed, and in the extreme case may even terminate in fibrosis, atrophy, thrombosis of the vessels and ischemic gangrene of the limb, necessitating amputation.

Whether actual blood vessel trauma has or has not been sustained can be determined only by careful observation at the site of the injury for evidence of vascular damage, by visualization of the path of the missile (whether or not it embraces a major vessel), and occasionally by the use of the oscillometer which would give information as to whether the collateral vessels have been shut down. Pathological examination, both gross and microscopic, of a vessel in spasm will show no abnormalities of structure.

Treatment of vasospasm resolves itself, in order of application, into: (1) débridement of all traumatized tissue and removal of the foreign body, (2) repeated paravertebral sympathetic blocks using novocain preparation, (3) periarterial sympathectomy and finally, (4) sympathectomy. All of these procedures are aimed at the removal of the sympathetic impulses which have occluded the lumen of the vessel. The use of the external heat above 88 to 96°F. to increase the vascular flow is

definitely contraindicated as this merely increases tissue metabolism and thereby increases the speed with which tissue necrosis and gangrene will appear.

LOCALIZED CONTUSION

It is not necessary that severance, partial or complete, result from trauma to the vessel wall. If the velocity of the missile be spent so that the wall is not penetrated but merely struck, or takes such a course that it merely bruises the wall and does not sever it, a contusion of the vessel wall is said to result. Often the missile is large and flat, and in its course merely slaps against the wall of the vessel without penetrating it.

In these cases of contusion damage to the intimal layer of the vessel is much more marked than is damage to the adventitia, and microscopic examination of the vessel will show marked fraying and tearing of the former layer. There is no definite treatment to be instituted on the vessel itself, but the usual careful débridement at the site of injury must be undertaken. However, if vasospasm results the outline given above should be followed to combat this complication.

The chief concern here is not in the lesion itself but with the complications that may result. Spasm has already been discussed and the others can be determined only by close observation of the patient, his general condition, as well as the progress of the local lesion. The resultant complications are: (1) local obliteration of the vessel, (2) blow-out or secondary hemorrhage, (3) traumatic aneurysm, and (4) embolism.

LACERATING WOUNDS

These are the direct wounds to the vessel wall, and are caused not only by the sharp missiles which impart a clean tear to the wall, but also by jagged objects which cause gaping lacerations and which occasionally tear out segments of the wall. For convenience these lacerations may be classified as: (1) complete or incomplete, (2) transverse or longitudinal. It has been shown in

experimental animals that an incomplete tangential laceration of a vessel wall will result in more profuse hemorrhage, (bleeding often continuing until the death of the animal) than does a complete severance of the vessel. In the latter case the elastic fibers cause a retraction of the severed ends into the surrounding fibrous tissue and a folding in of the intima and this, in association with the resultant vasospasm, often causes spontaneous cessation of the bleeding. The emergency treatment consists of the arrest of bleeding, either by pressure, tourniquet or by clamping and/or ligating the bleeding vessel. This is all that should be done at the site of the injury. Definite treatment is to be deferred until the patient reaches a hospital.

Treatment consists of débridement of the entire wound first, and then the paying of especial attention to the blood vessel itself. If the lesion is applicable to repair, suturing of the laceration may be undertaken using atraumatic needles carrying fine silk and including only the adventitia and media in the bite. The suture line should be re-enforced by a strip of muscle or fascia for added support. If there is a defect which cannot be bridged by the arterial wall itself, this may be overcome by flexion of the neighboring joint or a piece of vein wall may be sutured over the defect and used as a bridge gap. Recent work has been done with the use of cellophane and vitallium as a substitute for the wall. It is believed by most investigators that if excision of the vessel can be safely done without danger of gangrene of distal tissue (as radial or ulnar arteries, anterior or posterior tibial arteries) that this procedure is to be preferred to repair by suturing or end-to-end anastomosis. It has been observed in many cases that suturing is followed by thrombosis, arterial spasm and later by aneurysm of the wall of the repaired vessel. Regardless of the surgical procedure attempted full use should be made of all the adjuvants which the surgeon can obtain: blood, plasma, sulfonamides, penicillin, heparin, pre- and post-

operatively to prevent thrombosis. Also, postoperatively, optimum position and splinting for not too long a period should be instituted. At the end of two to three weeks immobilization should be discontinued and physiotherapy begun.

If it is decided that repair is not feasible and ligation of the artery must be done, this should never be "ligation in continuity" but ligation above and below the site of injury and removal of the complete segment of the artery. By this latter procedure the vessel walls are allowed to retract and become thicker, so that danger of slipping of the ligature and/or erosion of the vessel wall, due to the arterial pressure with secondary hemorrhage, is diminished, and additionally ligation and excision causes a complete interruption of the periarterial sympathetic nerves so that reflex vasospasm distal to the injury site will not occur.

TRAUMATIC ANEURYSM (PULSATING HEMATOMA)

When laceration of the arterial wall occurs, or when a contused wall "blows out," and the sinus to the exterior is a small or blocked, bleeding occurs into the perivascular tissue. The amount of hemorrhage that results is dependent on the site of extravasation. Where there is loose areolar tissue the hematoma will be extensive, and where firm fascial layers intervene it will be more confined and limited. Bleeding continues into the surrounding tissue until the pressure in the hematoma is equal to that of the arterial blood pressure at which time bleeding will cease. Clotting of the surface blood then occurs, which finally forms a firm organized fibrotic surface eventually becoming lined with a layer of endothelium, forming a sac resembling an aneurysmal dilatation in which a continuous flow of blood occurs. Beck and various other observers have stressed the fact that fibrosis and organization occur only at the periphery of the hematoma, the central portion remaining fluid.

The chief symptom is pain, of a variable

degree, often burning in nature, and not uncommonly transmitted down the extremity along the course of an involved nerve. Pressure of the pulsating hematoma on the surrounding nerves may also produce paresthesia, anesthesia and even in the extreme, paralysis.

The chief signs are those of a brawny mass of variable size appearing at the site of a penetrating or perforating wound. This may, but more often does not, pulsate. A thrill, evidenced during the systolic phase may be felt, but the diagnostic sign is obtained by auscultation when a bruit, occurring during the systolic phase, is audible. This bruit is definite, loud, and may be transmitted distally and proximally along the course of the involved vessel.

It is important to differentiate this mass from a post-traumatic abscess, since a casual incision may end in a disastrous result. Auscultation, and if doubt still exists, aspiration of the tumefaction will definitely determine with what we are dealing. Differential diagnosis of a pulsating hematoma as distinguished from an arteriovenous aneurysm also is necessary, as both the local and systemic effects of the latter differ from those of the former, and the treatment is different. It is my opinion that auscultation is the most reliable early differential point. If the bruit is continuous throughout the entire cardiac cycle, it is evidence of an arteriovenous aneurysm; if it is present only during systole, it is a pulsating aneurysm. There are, however, other differential points which will be described in the discussion of arteriovenous aneurysm.

The prime concern of the surgeon is whether conservative or radical therapy should be undertaken. The dangers of secondary hemorrhage, due either to erosion or infection, are ever present, and many a restless night is spent in anticipation of just such an occurrence. It would be advisable to act conservatively if the mass were not extensive and extravasation did not cause much discomfort. However, we have had several cases of injury to the

opliteal and femoral arteries in which repeated episodes of bleeding did occur and in which the patient complained of severe pain in the involved extremity. It is in these cases that prompt surgical intervention is definitely indicated.

It is necessary to have the patient in optimum condition preoperatively and this is attained by the use of adequate amounts of blood, intravenous fluids, sulfa drugs and penicillin. Complete blood counts and hematocrit readings should be frequently done so that a close check may be maintained on the blood status. The patient should have been typed, and cross-matched blood kept on hand at all times. The primary surgical procedure should be isolation of the involved vessel proximal to the point of injury and the throwing of a tape around it. This will serve as an efficient hemostatic agent if profuse bleeding should occur from the vessel during the operative procedure, and will be a constant source of comfort to the operator. A similar procedure distal to the site of injury should next be undertaken, and then the exploration of the lesion at the site of injury can be performed safely. It will be found that a large amount of clot will have to be evacuated before the arterial lesion can be visualized. In all cases that were explored it was necessary to doubly ligate and extirpate the damaged segments of artery since the lesion was always extensive and repair not feasible. The question of whether simultaneous ligation and removal of a segment of the companion vein should be performed is still a moot one, but we have believed that this is not necessary. As discussed in Nash's *Surgical Physiology*, exponents of both sides quote facts that show there is no marked advantage in either ligating or not ligating. Studies have failed to prove that by not ligating the large companion vein, stasis, with a fall in blood pressure on the venous side of the system, due to reduction of resistance, will occur and anoxia of the tissues result.

The incidence of gangrene of an extremity after removal of a portion of a major

artery is dependent primarily on the state of the collateral circulation, and this in turn is dependent on the amount of tissue destruction which has resulted from the injury. The incidence of gangrene after injury and subsequent ligation of a vessel, and in merely ligating the same vessel without preceding trauma reveals a greater frequency in the former. The following are the figures quoted by Hamilton Bailey:

Artery	Injury and Ligation Per Cent	Ligation Per Cent
Axillary	2.7	1.4
Femoral	26.2	17.2
Popliteal	34.7	26.6

Following the interruption of the blood supply, attempts at improvement of collateral circulation should be made. These procedures include repeated paravertebral blocks with novocain, the use of vasodilators as papaverin hydrochloride parenterally and alcohol per os and the use of external heat, but this latter must be rigidly controlled so as not to exceed 98.4°F.

ARTERIOVENOUS ANEURYSM

This interesting vascular phenomenon was first described in 1757 by John Hunter and was recognized by him for the exact condition that it is now known to us.

When the course of the missile is such that simultaneous laceration of an artery and vein in juxtaposition occur, the result is an arteriovenous aneurysm. A variable amount of blood is spilled into the surrounding tissues and the resultant hematoma may dissect along fascial planes as well as into soft tissue, but most of the higher pressured arterial blood is forced out of the rent in the artery and into the close lying vein to be returned to the pulmonary or portal circulation without ever having passed through the arteriolar and capillary bed.

Because of this shunt and resultant decreased vascular supply to the extremity

distal to the site of injury, local trophic and nutritional changes occur and concomitantly a greater strain is thrown on the heart which is forced to increase its cardiac output since: (1) the pressure head at the site of injury is lowered, and (2) the amount of blood returning to the heart is increased. This is reflected at first by tachycardia, and then by an increase in pulse pressure, cardiac dilatation, hypertrophy, and finally by cardiac decompensation. In addition to these general symptoms are the local symptoms of trauma and pain, of a burning nature, referred down the side of the extremity or along the course of the nerve trunks. In our experience this pain has frequently been severe and continuous necessitating narcotics for sedation.

The signs too are both general and local, the general ones being those of cardiac hypertrophy and finally decompensation. The local signs, which are the most important diagnostically and the first to appear, are a bruit and thrill over the site of injury continuous throughout the entire cardiac cycle. In 1890, an American surgeon, Branham, described a sign consisting of bradycardia produced by manual pressure over or proximal to the tumor. This is of definite aid in arriving at a diagnosis, and, in conjunction with the continuous bruit, is pathognomonic of arteriovenous aneurysm.

Therapy is radical surgery; but unless there is secondary hemorrhage or a rapidly enlarging mass, this is to be delayed for several months until proper collateral circulation can be developed by the body. When surgery is finally performed it is to be done in a bloodless field and a quadruple ligation with removal of the sac is the only procedure to be contemplated. Any other less radical procedure will be found to be worthless and attempts at repair of the arterial defect by the technic of Matas are so different due to the great numbers of vessels which have been developed that it is almost excluded by the technical difficulties. The postoperative results as reported by Elkin at the Army Vascular Center have been excellent.

SECONDARY HEMORRHAGE

No discussion of this topic could be concluded without a brief description of secondary hemorrhage. In our series of cases this was the most frequent vascular accident, and when it occurs is an immediate emergency and demands prompt treatment as bleeding may be so severe that exsanguination soon occurs. The etiology is varied, and the time interval between injury or operative procedure and secondary hemorrhage may vary from a few days to several weeks. The more common etiological factors are (1) slipping of a ligature, (2) erosion due to infection, foreign body, and bone spicule, (3) bleeding from traumatic aneurysm or arteriovenous aneurysm, and (4) contusion of arterial wall with subsequent blow out.

Bleeding may occur only once and be slight or it may be profuse, frequent and severe. The immediate treatment consists of: (1) constant firm pressure over the bleeding site applied manually or with an elastic bandage or by the application of a tourniquet proximal to the site of bleeding, and (2) measures taken to combat shock and collapse if the bleeding is severe. In these latter cases the use of type "O" blood without previous cross-matching is definitely indicated, and it has been our experience on occasions that with very severe bleeding when the red blood cell count falls below 900,000 that typing of the patient's blood becomes impossible.

If bleeding is recurrent, surgical intervention with ligation of the offending artery is imperative. The technic as previously described is to be carried out.

SUMMARY

1. The more common vascular injuries are described and discussed as to etiology, diagnosis and therapeutic procedures.

2. A note of caution as regards the use of the tourniquet is struck, and comment is made as to the advisability of encasing the limb in ice to decrease dangers of misuse, and concurrently facilitate the

readiness with which subsequent operative procedures can be performed.

3. It is advised to employ type "O" blood without previous cross-matching in cases of severe bleeding in which delay in administration of blood would be dangerous.

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ANEURYSMS vary in size from that of a millet seed to a child's head. They may be single or multiple. In order of frequency they involve the thoracic aorta, popliteal artery, femoral artery, abdominal aorta, subclavian artery, innominate artery, axillary artery, iliac artery and the cerebral and pulmonary arteries.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

TRAUMATIC HEMOTHORAX

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PRIOR to the war, opinion regarding the treatment of traumatic hemothorax, was divided among those who believed in the active treatment of aspiration with or without air replacement, and the conservative treatment. The former believed that the blood was a foreign substance which interfered with the cardio-respiratory function and its presence was a danger which might result in excessive adhesions and fibrosis. The conservative group held that aspiration *per se* was a greater menace and was responsible for a larger number of empyemas and that spontaneous absorption of the pleural fluid resulted in the vast majority of cases. The interest of the author was further aroused in the subject in 1941 after observing two cases of debilitating fibrothorax which resulted from traumatic hemothorax treated conservatively.

Does blood in the pleural cavity, in the case of a hemothorax, clot? Dr. Jerome Head in an article¹ stated, "One of the striking and unexplained aspects of the condition is that blood in the pleural cavity does not clot—either in situ or after it has been aspirated." In contrast, Dr. J. M. Clarke² said, "The problem of clotting. . . . It is usually stated that massive clotting does not occur in cases of hemothorax, due, it is suggested, to the constant respiratory movement defibrinating the blood. A layer of fibrin is deposited on the pleura and only clots of small size are to be found. There are, however, many exceptions to this general rule, for extensive clotting may occur." I have found large hemothorax cases in which there must have been minimal clotting because they were aspirated with ease. On several occasions, I have aspirated as much as 1,000 cc. of bloody fluid and after straining it, transfused it directly

back into the patient without ill effect. On the other hand, all of us have had the experience of encountering the clotted hemothorax in which repeated attempts at aspiration, yielded a few cc. of bloody serous fluid. What are the reasons or causes that produce clotting in some cases of hemothorax and in others it is not apparent?

I believe, that in every case, the clotting process in the pleural cavity is inhibited; but in every case a small amount of fibrin settles on all the pleural surfaces. The blood exerts an irritating action on the pleura which pours out a varying quantity of serum as a defensive measure. This loss of serum is as much a contributory factor in the production of shock in these cases as it is in burns. The inhibition of the clotting process of the blood in the pleural cavity may be due to the following factors: (1) The lack of contact with air; (2) the fact that in the majority of instances the blood in the pleural cavity is from the pulmonary circulation and may possess some anticoagulant; and (3) the constant commotion set up by the respiratory movements.

The factors that may contribute to the clotting of blood in the pleural cavity in traumatic hemothorax are: (1) The entrance of air into the pleural cavity from a laceration of the lung or from the external wound; (2) a considerable and varying portion of the blood may have originated from the systemic circulation as from an intercostal vessel; (3) contused and injured tissue may have a coagulant influence so that cases of clotted hemothorax are seen where there is more tissue damage particularly associated with fragmentation of ribs; and (4) the presence of bacteria in low grade subclinical infection may hasten clotting. Certainly there is a

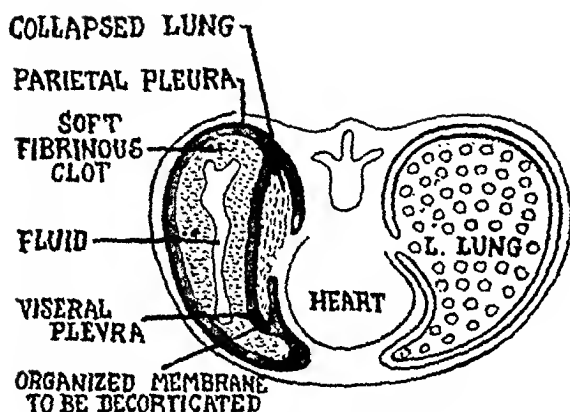


FIG. 1. Cross section of thorax, in clotted hemothorax.

greater amount of fibrin precipitated in the presence of *Staphylococcus aureus* than in streptococci.

Traumatic hemothorax accompanies all penetrating chest wounds to a greater or lesser degree. The source of the blood is usually from the pulmonary circulation of the injured lung. This type is seldom fatal because the rising intrapleural pressure soon equals that of the low pressure in the pulmonary circulation and the bleeding stops. However, bleeding from injuries to the intercostal and the internal mammary vessels and the large pulmonary vessels at the hilum of the lung, result in massive and sometimes fatal hemorrhage. In addition to the symptoms of hemorrhage and shock, the normal cardiorespiratory physiology is disturbed by progressive decrease in blood volume, cardiac output and vital capacity. There is a progressive resistance to the pulmonary circulation, the heart, and the great veins returning blood to the heart. The clinical picture is too well known to require further comment.

Treatment of hemothorax is directed toward restoring the disturbance of the normal cardiorespiratory physiological state by combating shock, maintaining sufficient oxygenation, increasing the blood volume with blood and plasma, and decreasing the intrapleural pressure by aspirations, until the patient's condition has become stationary at a safe level. Prior to 1943, the prevailing authoritative opinion in

the treatment of hemothorax was, as follows: (1) Small to moderate size hemothoraces were treated conservatively and usually resulted in spontaneous absorption with little or no sequelae. (2) In large hemothoraces, opinion was divided. Some favored conservative treatment pointing out the frequency of spontaneous absorption and the infrequency of empyema. Others advocated repeated aspirations to hasten recovery and prevent fibrothorax. Still others, advocated aspiration with air replacement after the method of Bastianelli.

In 1943, after the experiences observed in the African campaign, the Surgeon General's Office issued instructions that in all cases of hemothorax attempts should be made to free the pleural cavity of blood by aspirations without air replacement. Air replacement was to be avoided in order to obtain as a rapid a re-expansion of the lung as possible. Cases treated with air replacement resulted often in a pneumothorax with a fixed collapsed lung that subsequently required thoracoplastic procedures.

There were three types of traumatic hemothorax cases that were seen in the forward combat area in the surgical field and evacuation hospitals: (1) The penetrating or perforating chest case with a moderate or small hemothorax, in good general condition. He required little or no treatment beyond a minor débridement of his external wound and an intravenous injection of plasma and was quickly evacuated to a general hospital. (2) The case with a large hemothorax that required supportive treatment with blood transfusion. After a débridement of his wounds he was quickly stabilized by chest aspirations. He was evacuated to a general hospital in about seven days. (3) The patient with a large hemothorax that required supportive treatment with a thorough débridement including a thoracotomy. The surgical treatment in the forward hospitals consisted of thorough débridement of the wound or wounds, excising the skin wounds of entrance and exit, with excision of contused and injured

muscle tissue. Pieces of fragmented loose rib and foreign material were removed. If indicated, the wound was enlarged and the pleural cavity was entered and cleaned of all blood, fibrin or foreign material. Lacerations of the lung were explored and cleaned of clot or foreign material and sutured. If the missile was easily located, it was removed at this time. Hemostasis was made as complete as possible. The pleural cavity was dusted with a mixture of sulfanilamide and penicillin powder and drained with an intercostal rubber tube which was connected to underwater drainage. The wound was closed in layers except the skin which was dusted with penicillin and sulfanilamide powder and covered with vaseline. The tube was removed in three or four days.

At this point, it must be stated that all our wounded were liberally treated with penicillin. It was always plentiful, and treatment was started in forward hospitals and continued in the general hospitals. Many practiced injection of penicillin in varying quantities following chest aspirations. These patients received penicillin pre- and postoperatively and it undoubtedly was responsible for the excellent results in this war. The traumatic hemothorax cases that reached the general hospitals in the communication zone were of four types: (1) The patient that required little treatment such as aspiration of a small or moderate hemothorax or a secondary closure of his wound. (2) the patient with a large hemothorax who required repeated aspirations and supportive treatment; (3) the patient who had had repeated aspirations and now had an infected hemothorax which required a thoracotomy for exploration, removal of a foreign body and drainage. We had six infected hemothorax cases due to *Bacillus Welchii*, treated successfully with drainage, sulfanilamide, penicillin and serum; and (4) the patient with a clotted hemothorax.

The diagnosis of a clotted hemothorax was never a problem. The involved hemothorax appeared fixed and immobile on

respiration. All physical signs of fluid were present. The x-ray usually showed a uniform density of the involved hemithorax with a diminution in its size as evidenced by narrowed interspaces and very often a raised diaphragm. Multiple fluid levels were frequently seen and the mediastinal structures were often not displaced. Aspiration of small amounts of blood stained serum was the usual finding. If several attempts at aspiration over a period of three or four weeks failed to show any sign of reexpansion of the lung or absorption of the exudation, a thoracotomy for decortication was indicated.

In the case of the clotted hemothorax, we were faced with the following problem.

We had a traumatic hemothorax of three or four weeks' duration that was not influenced by repeated aspirations. It was feared that a fibrothorax was inevitable. Fortunately, our first case soon after D-day had in addition to a clotted hemothorax a large shell fragment in the right lower lobe. The indication for operation was primarily to remove the large shell fragment. On opening the pleural cavity through a large intercostal incision, the parietal pleura was thickened and the pleural cavity was filled with loculations of bloody serum in the midst of jelly-like reddish yellow fibrinous clots. This was all removed with the gloved hand, sponges, and ring forceps. The lung was found fixed and collapsed against the mediastinum and covered by a dense thick fibrinous exudate. There was no respiratory motion of the lung or the diaphragm, which was elevated and also fixed and rigid and covered with a similar exudate. The costophrenic angle was obliterated. The shell fragment could not be felt. An incision was made through the exudate covering the lung down to the pleura. The lung was seen to balloon through the incision. With the gloved finger and gauze on the end of a clamp, this membranous exudate was easily peeled off the lung leaving a glistening visceral pleura. The entire lung surfaces were cleaned in this manner. The laceration in the lung was

located, cleaned of clot and débris and the shell fragment removed. The laceration was sutured with two rows of chromic catgut. The pleural cavity was irrigated with warm saline solution and dusted with penicillin and sulfanilamide powder. A large size rubber tube was inserted into the pleural cavity through the ninth interspace posterolaterally which was connected for underwater drainage. The thoracotomy wound was closed in layers. Postoperative x-ray showed the lung expanded and the drainage tube was removed on the fourth day.

Following the marked success in this case, five additional decortications were performed in England with the same result. In Belgium, we continued to treat clotted hemothorax cases by decortication and performed the operation eighteen times with uniform success. In several cases we had to resort to aspirations of small residual localized hemothorax or to resort to a rib resection to drain a localized empyema. Fortunately, I had the opportunity to see an x-ray of the chest of one of the first patients on whom I had performed a decortication in England in June, 1944. In January, 1945, he was admitted to a general hospital in Liege, Belgium, for a hernia operation. He had been returned to active front line duty in November, 1944, and had served through the Battle of the Bulge. The x-ray showed a normal chest except for a slight amount of pleural thickening in the right costophrenic sinus.

Opinion was divided in the forward hospitals as to whether it was necessary to drain all thoracotomy cases. We encountered many secondary hemothoraces and empyemas in our general hospital among those that were not drained. This convinced us of the necessity for drainage. It is interesting to find support for this fact in the article by Kay and Meade.³ The authors had the advantage of studying the cases after their arrival in this country, hence their last period of hospitalization. They found that in 189 patients that had thoracotomies overseas, eighty-one were closed with drainage and 108 without. In

those closed with drainage 82.7 per cent healed without requiring secondary operations as compared to 43.5 per cent of those closed without drainage.

Another and very interesting group of figures by these authors illustrates the value of active treatment of hemothorax:

	No. of Cases	No. of Infection	Per Cent
Group treated by thoracocentesis	225	38	16.8
Group treated by operation.....	156	76	48.7
Group treated without definite treatment.....	74	30	45.9

SUMMARY

The problem of hemothorax has been presented from the standpoint of its pathology and management. The results of the experiences encountered in this war have cleared some doubt and uncertainty in regard to treatment and have offered many of us an opportunity to observe the pathology of hemothorax. The mortality and morbidity of chest wounds in this war has been greatly improved in this war by: (1) Excellent early primary surgery in the hospitals in the combat zone; (2) the availability of excellent endotracheal anesthesia; (3) the abundance of the chemotherapeutic agents penicillin and sulfanilamide; (4) the abundance and availability of blood and plasma; (5) the recognition of the value of postoperative endotracheal and bronchoscopic suction.

Active treatment after careful evaluation, in the form of chest aspirations appears to give the best results as compared to conservative treatment. In the case in which bleeding continues a thoracotomy is indicated. In cases of large clotted hemothorax, thoracotomy and decortication offers a prompt return to a normal anatomical and physiological restoration of the involved lung.

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THE TRANSVERSE INCISION IN ABDOMINAL SURGERY

A FIVE-YEAR STUDY

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FIVE years ago we decided to undertake a clinical investigation of the various types of abdominal incisions. The conclusions presented here have resulted from our experiences in this study with 480 surgical patients in whom abdominal entry was effected through a transverse or modified transverse incision.

Too frequently the abdominal wall as a surgical entity is stripped of any significance and is regarded only as an ever present barrier to existing intraperitoneal disorders. However, unless this structure is viewed in proper perspective, its importance may be brought into sharp focus by the occurrence of embarrassing and often serious postoperative complications. Often these can be avoided by a careful diagnosis, adequate preoperative care and the use of incisions based on sound anatomical and physiological principles.

There are at least four criteria which a successful abdominal incision must meet. It should: (1) Provide adequate surgical exposure to the operative area; (2) minimize trauma to motor nerves and aponeuroses; (3) afford opportunity for extension of the original incision should this prove necessary; and (4) produce a narrow, firm and slightly cicatrix which is comfortable during convalescence and which affords a degree of ultimate cosmetic satisfaction to the patient.

Reasonings that incisions which meet the above mandates are somewhat more difficult to execute and therefore should be discarded for the simpler and perhaps more conventional technic are pernicious and not in the best interests of the patient.

The merits of a transverse abdominal section cannot fail to be appreciated if it

is compared with the anatomical characteristics of the vertical incision.

EXPOSURE

Considering the vertical mode of entry it becomes apparent that operative procedures are usually performed through only one end of the incision. It has been a dictum in pelvic surgery for example, that "an inch below is worth two above." As a corollary Lahey recently emphasized the importance of extending paramedian incisions in the upper quadrants for better exposure to the costal margin. In the latter instance, "an inch above *may* be worth two below." In a six-inch vertical incision only about three inches forms the functioning aperture, the remainder serves merely to enhance its effectiveness. On the other hand, a transverse incision is planned to lie almost entirely over the operative field. The Phannensteil incision affords splendid visualization of the pelvic and lower abdominal viscera, but to attempt upper abdominal surgery through it is sure to produce unsatisfactory results from lack of adequate exposure. The transverse or G. G. Davis appendectomy incision will give excellent access to the cecal area; but if exploration discloses that a hysterectomy is required, we believe it wiser to repair the small initial incision, and then obtain entry, trouble-free, through a better planned one. The point to emphasize here is the particular need for an accurate preoperative diagnosis in which a transverse section is to be employed.

In the technical fulfillment of adequate exposure the disposition of one or both rectus muscles frequently presents a problem to the operator. In any transverse in-

cision, regardless of location or extent, these muscles represent the only structures encountered whose component fibers are perpendicular to the anatomical plane of cleavage. To cut these muscle fasciculi "against the grain" appears at first physiologically unsound. Some authorities emphasize the need for preliminary suture fixation of the rectus muscle to fascia prior to transection. They state that if this step is not taken, the cut ends of the recti will be released from tension(?) and will retract beneath the fascia, making it impossible to restore their continuity later. Five years of technical experience testify to the profound incorrectness of this statement. Not only do the recti fail to exhibit any elastic properties whatsoever, but during closure of the incision it is entirely unnecessary to approximate the muscle layers. This approximation occurs automatically with closure of the anterior and posterior rectus sheaths. We have not had occasion to reoperate any patient in this group and thus obtain first-hand information as to the ultimate fate of the muscle incision, but animal experiments and the observations of competent investigators show beyond doubt, that fibroblastic proliferation and healing by secondary union produces a new *linea transversae*.

The decision to retract or divide the recti depends on the degree of exposure required. In all adnexal operations and uterine suspensions, lateral retraction has supplied adequate exposure for us. For hysterectomy the procedure will usually vary with the patient's physique. In a slender individual, we have done total uterine ablation, disposing of the recti by retraction. In the obese, unilateral or bilateral transection may be indicated and should be performed without hesitation. Transverse upper abdominal incisions should be made at the level of the ninth costal cartilage, and usually one rectus muscle must be severed. The exposure thus afforded is magnificent, much better than that obtained by a vertical incision of similar length.

TRAUMA

In considering this very important topic, a few pertinent anatomical facts may be reviewed with profit. Although the recti muscles lie parallel to the sagittal plane of the body the fibers of the important fascial structures ensheathing them extend in an opposite direction and are morphologically distinct. This fact is easily overlooked because of the intimate connection between these two groups, an affinity most marked between the recti and their *anterior* fascia. Cleavage planes in the fascia of the external oblique, internal oblique and obliquus abdominis transversus are either transverse or slightly oblique, and at the level of the umbilicus their transverse direction is quite apparent. This applies also to the *transversalis* fascia and the parietal peritoneum. On the basis of this characteristic, Gurd suggested the advisability of making all transverse incisions within two inches of the umbilicus either above or below. There is much to be said in support of this technic based as it is on careful observation and long experience.

Regarding nerve injury, we have always been wary of such trouble in the long paramedian incision, and the closer this incision approaches the *linea semilunaris* the greater becomes the incidence of this avoidable complication. The cutting of any two adjacent intercostal nerves may devitalize the rectus segment supplied and the muscle atrophies between the incision and the midline, resulting in either a definite hernia, a diastasis or an unsightly asymmetrical bulge. A transverse incision if properly made, affords complete protection against this eventuality because in nearly all cases the line of incision is parallel to the nerve trunks and usually lies between them. In this series we have had not one postoperative hernia or wound disruption.

With regard to blood-vessel injury the picture is considerably different. Many more small arteries and their accompanying veins are severed in performing the

transverse incision. While effecting hemostasis, therefore, a slightly longer period of time is consumed in entering the peritoneal cavity. However, this allows for only minor criticism. The recti may be clamped and cut, and in the lower abdomen there usually will be no vessels requiring ligation within the muscle. The inferior epigastric vessels which lie just external to the parietal peritoneum, gradually become more superficial as they proceed cephalad, finally piercing the deep, internal oblique fascia until their anastomosis with the descending superior epigastric which lies well *within* the body of the rectus muscle. Thus when the recti are incised across the *upper* abdomen these vessels must be carefully searched for in the muscle and ligated, as they can be the source of profound hemorrhage.

ENLARGEMENT

Extension of transverse incisions to produce additional exposure is no problem for within the limits afforded by the costal margins in the upper abdomen and between the pubic rami below there is more than ample room for incisions of sufficient length to allow excellent visualization. It is only when the incision is incorrectly placed too low or too high that bony formations begin to hinder its augmentation.

OPERATIVE SCAR

If the surgeon will carefully analyze,

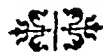
as we have done, the subjective symptoms of patients postoperatively, he will be afforded ample justification for the use of this technic. Closure without tension produces a minimum of discomfort for the patient, and this can be further reduced by maintaining the knees in slight (30 degree) flexion over a small pillow. Straining, coughing or retching, if present, shorten the recti and approximate the edges of a transverse incision; longitudinal incisions are inclined to gape and separate under identical conditions.

Pulmonary atelectasis caused by shallow breathing and poor aeration due to painful incisions is likewise minimized, and within five days the majority of patients become ambulant.

From a cosmetic standpoint the results are ideal. The scars rarely widen beyond the thickness of a scalpel blade even in the presence of soft drains through the incision. In the female patient the location of the cicatrix is such as to allow conformation with fashions exposing the midriff, a feature of no little importance to the fastidious.

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NON-INFECTIOUS ILIOPECTINEAL BURSITIS

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ILIOPECTINEAL bursitis is not an uncommon occurrence, but apparently it is not commonly recognized in its earlier stages. Since the condition was first described by Fricke in 1834 and elaborated by Joly in 1847, there have been a total of only seventy-three cases reported in the literature. In 1933, O'Connor published a most comprehensive article on this subject in which he added thirty-three cases of his own and was the first author to recognize the condition before a tumor mass presented itself in the groin. In twenty-one of his cases, there was neither swelling nor palpable tumor in the femoral triangle. Three additional cases have been reported since those of O'Connor, but in all three of these rather large tumor masses were present.^{3,7} It seems noteworthy that of the seventy-three cases recorded, only twenty-one have been recognized in the acute stage when the most promising results from treatment may be expected.

ANATOMY

The iliopectineal (or iliopsoas) bursa is but briefly mentioned in the anatomical text books. Cunningham says: "The psoas tendon passes over a thin portion of the capsule between the upper ends of the iliofemoral and pubo-capsular ligaments, with a small sub-psoas bursa intervening; sometimes there is an opening in the capsular ligament under the tendon, and the bursa is then continuous with the synovial membrane of the joint." Several anatomists have investigated this bursa. Lund studied eighteen cadavers and found the bursa present in each one. Chandler in his study of the iliopsoas bursa used 206 adult cadavers, five fetuses (five to seven months), ten baby cadavers and twelve stillborn babies. He was able to demonstrate the bursa in all but three specimens. These

three were adult bodies. Out of a total of 400 bursae studied, he found that sixty-one (14.5 per cent) communicated with the cavity of the hip joint. Kessel dissected 535 adult specimens and found a communication between the bursa and the joint cavity in 15 per cent. The bursa has been found to vary in size, but as a rule, it averages about 5 to 7 cm. in length and 2 to 4 cm. in width. It extends proximally to the pectineal eminence and may extend over the brim of the pelvis. Chandler concludes that the communicating foramen is not a result of development, but is due to friction of the psoas tendon and also that the bursa exists before birth. (Fig. 1.)

SYMPTOMS AND PHYSICAL FINDINGS

Pain in the hip region, which varies from excruciating to mild discomfort, is usually the first complaint of the patient. This pain may or may not radiate down the front of the thigh to the knee. The patient, or his intimates, will almost invariably notice a change in his gait. Early in the disease, there may be only a shortening of the stride on the affected side as a defense against hyperextension of the hip. Later the extremity will be carried with the hip and knee flexed and the thigh adducted and externally rotated to relieve the pressure of the psoas tendon on the underlying bursa. Fullness or swelling in the groin will not be observed unless other symptoms have been present for several months or longer. Varying degrees of weakness of the extremity was a complaint in over 90 per cent of the cases reported in the literature.

Iliopectineal bursitis is most frequently seen in individuals during the first three decades of life; therefore, a history of trauma, excessive use or repeated strain of the extremity is easily elicited.

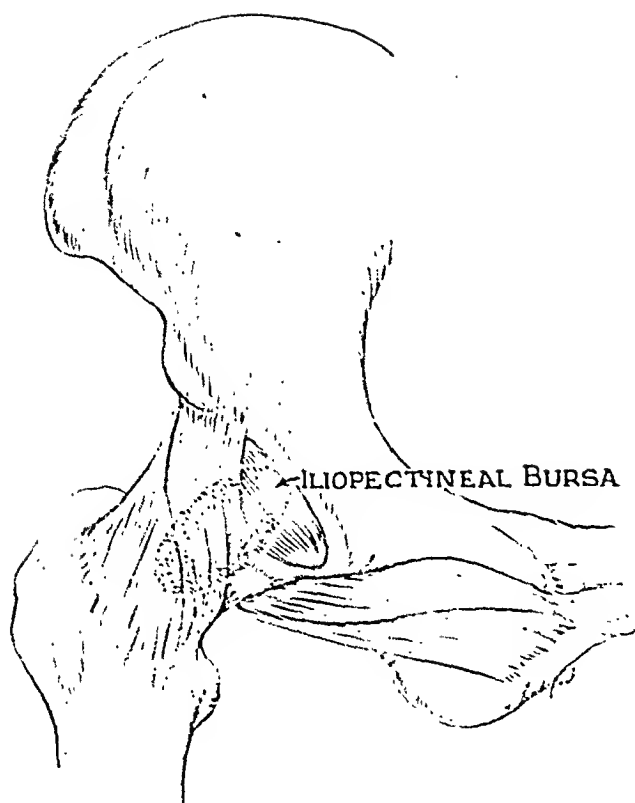


FIG. 1. The iliopectineal bursa is diagrammatically represented to show its direct relation to the hip joint.

Examination will reveal few but definite physical findings. The hip will be held in various degrees of flexion, and usually in adduction and external rotation. This may be so exaggerated as to produce a marked tilting of the pelvis and apparent lengthening of the affected limb. Pain is elicited by hyperextending, abducting or internally rotating the thigh. Tenderness to pressure over an area about 2 cm. in diameter, just below Poupart's ligament and lateral to the femoral pulse and mid-way between the anterior superior spine of the ilium and the pubis, is a constant finding and may be said to be almost pathognomonic of iliopectineal bursitis. Atrophy of the thigh or tumor of the groin are late findings. (Fig. 2.)

X-ray examination of the hip joint will be negative except in more elderly individuals in whom hypertrophic changes may be noted. It is generally thought that hypertrophic changes in the hip region are a predisposing factor to iliopectineal bursitis and doubtless accounts for its in-

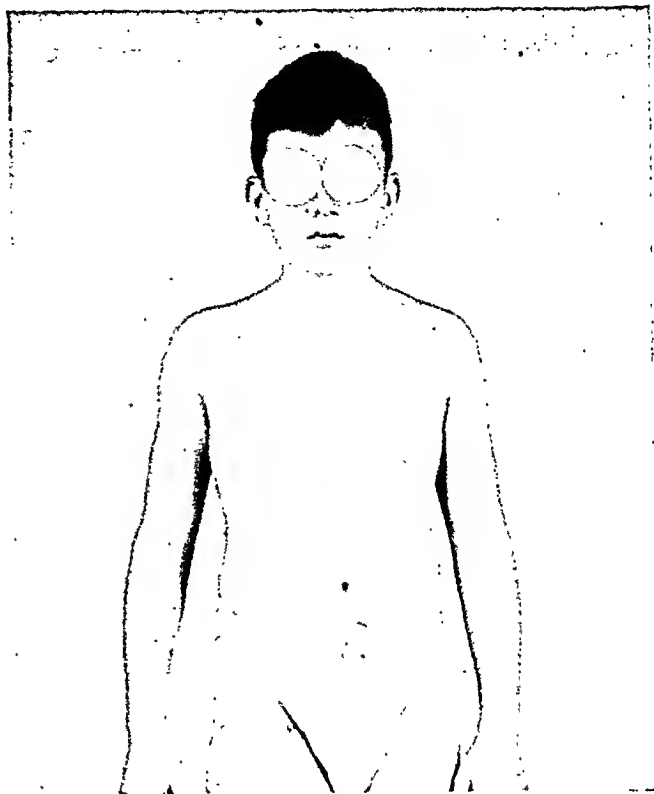


FIG. 2. (CASE 1.) X marks the area of tenderness characteristic of iliopectineal bursitis. The right hip is held in flexion with adduction and moderate external rotation of the thigh.

cidence in the older, more sedentary individuals.

DIFFERENTIAL DIAGNOSIS

Iliopectineal bursitis must be differentiated from hip joint disease. Since in intra-articular disease of the hip muscle spasm limits all hip movements and in bursitis adduction, flexion and external rotation can be painlessly accomplished, the differentiation should be easily made.

In late cases with the presence of a tumor mass inferior to the inguinal ligament, cold abscess, perinephritic abscess pointing in the groin, femoral and inguinal hernia, varicosity of the saphenous vein, hydrocele of the cord and lymphadenopathy must be considered in the differential diagnosis.

TREATMENT

Rest is the essential factor in the treatment of iliopectineal bursitis. O'Connor states that without rest other measures are worthless. The application of heat will be found gratifying to the patient and doubt-

less aids in the absorption of fluid and diminution in the thickness of the membrane of the bursa. Simple bed rest, even with the addition of Buck's extension, does not afford sufficient immobilization. We believe a short hip spica cast with a window over the femoral triangle, for the application of heat, will diminish the period of recovery. It must be borne in mind that even with the most adequate treatment, many weeks will be consumed before the patient is symptom free.

Due to the slow recovery, there arises the temptation to hurry the process by needling the bursa. We cannot recommend this procedure in acute cases; but if resorted to, the surgeon must adhere to strict aseptic technic, bearing in mind that in 15 per cent of the cases, there is a direct communication between the bursa and the cavity of the hip joint.

Surgical removal of the bursa is only necessary in chronic cases of long standing.

CASE REPORTS

One of us (D. C. H.) recalls making the diagnosis of acute iliopectineal bursitis six times during a five-year period in the Army; but since the complete records of these patients are not available, they will not be presented here. We wish to present two cases that are typical of this condition.

CASE 1. P. S., a white male, aged twelve, was first seen on December 10, 1945, complaining of mild pain in the right hip region and a marked limp. About three weeks previously, he was injured while playing football and noticed a slight pain in the hip at that time. The father stated that he noticed the boy walking with a shortening of his gait, but attributed it to an affectation. The limp grew more noticeable after one week and an osteopath was consulted. Osteopathic treatments were instituted and continued for about two weeks. The family was then advised to consult an orthopedist.

Examination revealed a well developed boy walking with difficulty. The right hip was held in 30 degrees of flexion, adducted and externally rotated. There was a marked tilting of the

pelvis producing one inch apparent shortening of the well leg. Attempts to extend the hip aggravated the pain as did attempts to abduct or internally rotate the extremity. Other movements of the hip could be actively and passively accomplished without pain. There was tenderness to pressure just lateral to the femoral vessels and inferior to the mid-point of Poupert's ligament. There was no fullness nor mass noted in the region. Examination of the spine and other joints and x-rays of the pelvis revealed nothing abnormal.

The patient was placed on bed rest with hot applications and diathermy to the hip region for thirty days. There was only slight improvement. He was then placed in Buck's extension and the hot packs continued. After fourteen weeks, the symptoms have completely subsided with a complete range of painless motion in the hip.

CASE II. F. J. M.,* a fifty-six year old white male, employed as a boilermaker, was admitted to the hospital on January 7, 1946, complaining solely of pain in his right groin. The pain had begun suddenly the day before upon arising. He located the pain just below the mid-point of the inguinal ligament and stated that it was aggravated by walking and caused him to limp. There was no radiation to the knee. No history of trauma could be elicited. Past history was of no significance, except five days before admission, he had struck a nail in the right heel. In February, 1944, he had been admitted to the hospital complaining of backache. X-rays of the spine and pelvis were negative at that time.

Examination revealed a middle-aged white male of stenic habitus, apparently in acute pain. His stride was noticeably shortened on the right side and the hip was held in slight flexion. Upon assuming the supine position in bed, the patient held the hip in a position of flexion, adduction and external rotation. Attempts to move the extremity from this position produced severe pain. There was moderate tenderness at the site of pain, just inferior to the mid-point of Poupert's ligament and just lateral to the femoral vessels. Several "shotty" lymph nodes were palpable in the inguinal region, but were not enlarged nor tender. There was no fullness, increased heat or redness. Reflexes were normal.

* This case is presented through the courtesy of Dr. Joe R. Gandy, Southern Pacific Hospital, Houston, Texas.

All laboratory data, including hemogram and urinalysis, were negative. Temperature, pulse and respiration were normal.

The patient was placed on absolute bed rest. He received diathermy to the right inguinal area once daily, sodium salicylate gr. 20 three times daily, and penicillin, 30,000 units, every three hours for a total of 660,000 units. Tetanus antitoxin, 1,500 units, was administered on admission, because of the history of nail puncture. The penicillin was ordered by the intern before the diagnosis was established.

The patient was discharged, improved, from the hospital on January 10, 1946, to be followed in the out-patient department. Pain was elicited on extension, internal rotation and abduction of the hip at this time.

CONCLUSIONS

1. Iliopectineal bursitis must be diagnosed early if complete recovery is to be expected in a reasonable length of time.

2. Its signs and symptoms are definite and the differential diagnosis should not prove difficult.

3. Complete, absolute rest of the part

with application of heat is the most efficacious therapy.

4. The location of tenderness in iliopectineal bursitis is so constant and definite that it may be said to be almost pathognomonic of the condition.

5. Needling of the bursa is not necessary in the acute stage of this process.

6. Surgical intervention is only warranted in chronic cases of long duration.

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BLOOD CELL JEL FOR CHRONIC SURFACE ULCERS*

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THE healing of chronic surface ulcers is one of the most discouraging problems the average physician sees in his office. It is a cause of considerable forced invalidism with its attendant economic loss.

We have developed a preparation called "Blood Cell Jel" at Mercy Hospital, that has healed surface ulcers of the legs. Table 1 shows a break-down of seventy-one cases as treated to date:

TABLE 1

Sex	Age			Blood Type	Etiology	Location			
M	20	20-30	1	AB	3	Varicose ulcers	65	Rt. leg	21
F	51	30-40	11	A	32	Arteriosclerosis	2	Lt. leg	33
		40-50	13	B	10			Both legs	17
		50-60	23	O	26	Traumatic	2		
		60-70	13			Burns	2		
		70-80	10						

Wassermann tests were all negative except for one case, a sixty-two year old female (positive in September, 1945). The Wassermann was negative January, 1945, and October, 1944. No clinical evidence of lues was evident at this time.

The number of treatments required to heal ulcers varied from six to 112. Of all patients treated, seven had recurrences only to heal on repeated Blood Cell Jel dressings.

Moorhead and Unger¹ were the first to report the use of red cells. They used them successfully in the treatment of infected burns and open joint lesions as early as 1942.

Seldon and Young² have used dried red blood cells in infected surface wounds, and to quote their conclusions, "The results have not been uniformly beneficial, but are

sufficiently promising to warrant more investigation and work along this line."

Our interest in the development of a Blood Cell Jel resulted from a study of the published reports of Murray and Sharr³ of the Blood Plasma Bank of the Navy Hospital, Philadelphia, Pennsylvania. They made a preparation, using blood cells, tragacanth, and hexalresorcinol, which is applied as a paste to the ulcer areas.

The Blood Cell Jel developed at Mercy Hospital is jelly-like in consistency and is applied by means of a syringe, a technic I shall discuss later in this paper. We have used this preparation for the past seventeen months and are just as enthusiastic about its results now as we were after the first two months it was prescribed.

Writer has used dried blood cell powder,* tyrothricin, penicillin ointment (500 units per Gm.), and two different chlorophyll ointments, one with and one without benzocaine, only to come back to Blood Cell Jel. The latter is well tolerated by every patient which has not been my experience with other preparations used.

PREPARATION OF BLOOD CELL JEL

The availability of blood cells had its beginning at the onset and subsequent days of World War II. Red cross donor centers were sending thousands of units of blood to plasma processing centers with the result that a use for the cellular elements that remained had to be found. The military service were interested only in dried plasma at the time. Hence, dry red cell powder, blood cell paste, and Blood Cell Jel were developed.

* Supplied by Sharpe and Dohme.

* From the Department of Surgery, Mercy Hospital. Read at the Bacelli Medical Club Meeting, January 15 1946, Hotel Statler, Buffalo, N. Y.

The blood cell jel is prepared from blood of a recent donor, the type corresponding to the prospective ulcer patient. Plasma is aspirated in the usual aseptic manner, leaving the cellular elements. To this is added the gum suspension base. We have used tragacanth, one of the commonly used commercial gums, as suggested by Murray and Sharr.³ Experiencing difficulty in getting an unlimited supply of tragacanth, we were advised to try a substitute gum preparation, namely, sodium-carboxymethylcellulose.* It is used exclusively as our vehicle for applying the blood cells to the ulcers.

Methyl-cellulose is soluble in cold water, but insoluble in hot water. When an aqueous solution of methyl cellulose is poured on a glass plate and allowed to dry, it produces a film which is tough, elastic, clear, quite transparent, has good resistance to twisting, and is insoluble in such organic solvents as acetone, ethyl alcohol, methylacetate, benzol and others.

We make an aqueous colloidal mixture by using 5 Gm. of methyl-cellulose dissolved in 95 cc. of distilled water. The mixture is then placed in a water bath at 100°C. for twenty minutes. The sodium-carboxymethylcellulose comes out of solution

TABLE I
TYPICAL CASES ON HOSPITAL FILES

Name	Sex	Age	Blood Type	Type of Ulcer	Duration	Culture	No. of Treatments to Heal
E. F.	F	50	IV-O	Varicose ulcer of leg	7 wk.	Staph. aureus	51
F. T.	M	55	IV-O	Multiple varicose ulcers of leg	11 mo.	No growth	15
H. L.	F	46	II-A	Varicose ulcers of leg	2 yr.	No growth	24
A. L.	F	74	II-A	Traumatic ulcer of leg	7 wk.	No growth	18
A. R.	M	32	III-B	Varicose ulcer of leg	4 yr.	No growth	6
S. C.	F	56	IV-O	Ulcer along incision for mastectomy	.....	No growth	41
R. B.	F	44	IV-O	Varicose ulcer of leg	.....	Staph. aureus	21
A. M.	F	59	II-A	Varicose ulcers of leg	2 yr.	Staph. aureus	33
C. P.	F	54	II-A	Ulcer of leg	.....	Staph. aureus	14
J. W.	F	72	.....	Varicose ulcers of legs	.....	Staph. aureus	112

Sodium-carboxymethylcellulose is a coarse grey powder and is a cotton-like substance. It forms colloidal aqueous solution and replaces a number of binders, adhesives, and emulsifiers, such as glue, starch, gum tragacanth, and others. It has other advantages: (1) high chemical stability, (2) neutral in aqueous solutions, (3) resistant to acids and bases, (4) stable to light, (5) high emulsifications and dispersive power, (6) good film strength, (7) no tendency to ferment or mildew, and (8) good miscibility.

* Hercules Powder Company, Wilmington, Delaware, supplied the sodium-carboxymethylcellulose used in this clinical study.

when heated. However, when the mixture is cooled, it again goes into solution. Twenty-five cc. of a 5 per cent solution of sterile sodium-carboxymethylcellulose is added to 250 cc. of blood cells of the prospective patient's blood type. Murray and Sharr³ used type O blood in making their paste. We use a jel that corresponds to the patient's blood type, giving us a crimson-red jel. In the past four months we have added 200,000 units of penicillin to each unit (250 cc.) of red cells.

The technic suggested for the use of the Blood Cell Jel is in three phases. The pre-treatment consists of: (1) complete blood count, (2) a Wassermann test, (3) typing of

blood, and (4) a culture of the base of the ulcer.

The minimum requirements for the application of the Jel are: (1) hospital treatment, (2) all equipment to be sterile, (3) Blood Cell Jel to be prepared and tested for sterility, (4) a syringe (5 to 10 cc.), (5) cotton applicators, (6) vaseline gauze strips, and (7) Abd pads and bandage (two inch).

After treatment consists of: (1) Saphenous ligation performed when indicated, after ulcers are healed, (2) patient is advised to elevate feet (higher than knees) for fifteen minutes three times a day, (3) coco butter is applied to healed ulcer area to keep the scar soft and pliable, and (4) Ace bandage or elastic stockings are worn.

The blood cell jel is kept at 2° to 5°C. and is taken out of refrigeration and immediately applied to ulcer by syringe. It is worked into the ulcer bed by sterile, gauze-tipped applicators. A thick film is applied, after which strips of sterile bandage, three inches by six inches, impregnated with vaseline, are applied and a single Abd pad applied and then the bandage. The dressing is changed daily. As Murray and Sharr³ reports, I have observed no evidence of Blood Cell Jel on the vaseline dressing or the ulcer twenty-four hours after the dressing was changed, indicating that it was completely absorbed. A few typical cases taken from our files are shown in Table I.

CONCLUSION

1. This paper confirms the observations and findings reported by Lieut. Murray and Capt. Sharr³ at the Blood Plasma Bank of the Navy Hospital, Philadelphia, and pre-

sents our experience with seventy-one cases of chronic surface ulcers over a period of seventeen months.

2. Sodium-carboxymethylcellulose is now being used exclusively as a matrix for our Blood Cell Jel. In infected cases, the discharge decreases, and the patients with severe pain secure relief much sooner than with any other preparation. We ascribe this to the film affect of the sodium-carboxymethylcellulose.

3. I give the Blood Cell Jel therapy to the ulcer patient, using the corresponding blood type.

4. Blood Cell Jel apparently adds needed protein and nutritional elements needed to heal surface ulcers.

The writer is grateful for the efforts of H. J. Daney, chemist, and Phillip Smyntek for their assistance in obtaining sodium-carboxymethylcellulose. The success of this problem would have been impossible without the untiring efforts and enthusiasm of Sister Mary Gertrudis and Sister Mary Mareella, of the Laboratory Department, and Sister Mary Vincentia, of the X-ray Department.

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DIAGNOSIS OF THENAR SPACE ABSCESS*

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ABSCESS of the thenar space is not usually followed by the severe local morbidity so often seen with the assumed when the probing clamp enters a normal space because the presence of pus has been suspected erroneously. Following

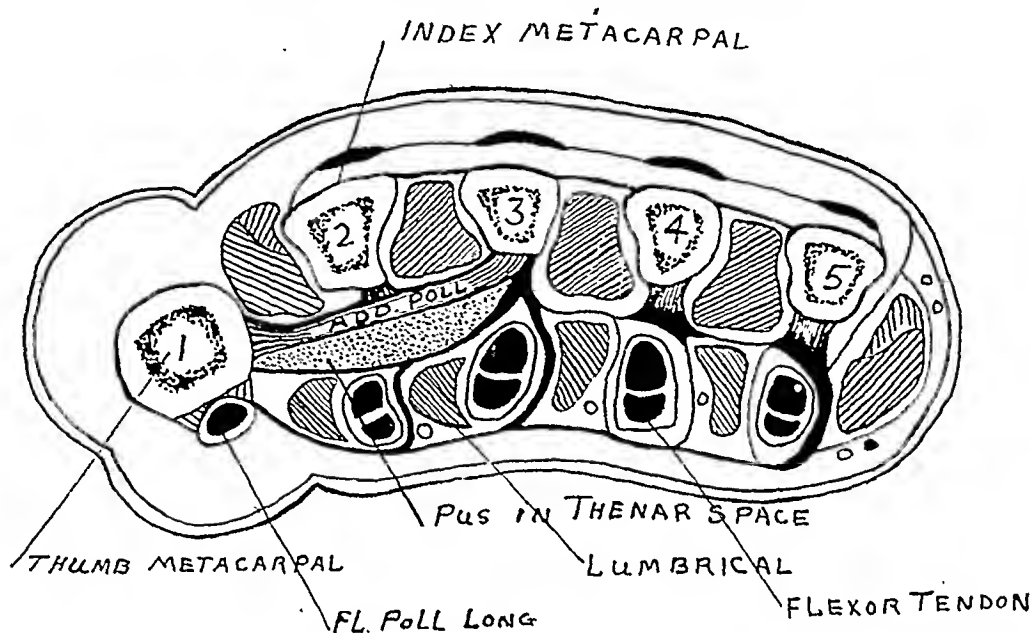


FIG. 1. Cross section of the hand through the metacarpals to show the thenar space distended with pus.

more common lesion of tenosynovitis. Much of the dread of septicemia has waned since the advent of effective bacteriostatic agents.

Nonetheless, significant limitation of motion of the thumb, especially that component controlled by the adductor pollicis muscle, will be encountered in direct proportion to the delay in drainage of the space. For maximal recovery of function of the hand, it is obvious that early drainage must be performed.

However, the non-localized infections of the base of the thumb, such as cellulitis and lymphangitis, will not be improved by incisions, and, if such errors of interference are made, the consequences of possible inoculation of the thenar space must be expected, as well as the risk of blood stream dissemination of the organisms. The greatest unnecessary local risk will be

such a maneuver the tear in the fascia overlying the adductor muscle rapidly heals, but the organisms have been implanted in an excellent culture medium. The stage has been well set for the development of a subsequent abscess. I have seen two patients whose space had been opened in search of pus which did not exist at the time, but who developed a severe space infection within a few days. In both cases a cellulitis had been incised because the surgeon had believed that a deep abscess was also present.

Reference to Figure 1 will show that the thenar space, which lies between the adductor pollicis posteriorly and its overlying fascia anteriorly, is very deeply placed in the hand. Direct examination is thus not possible because the area is covered posteriorly by the dorsal interosseous muscle of the index finger and

* From the Surgical Service, Gallinger Municipal Hospital.

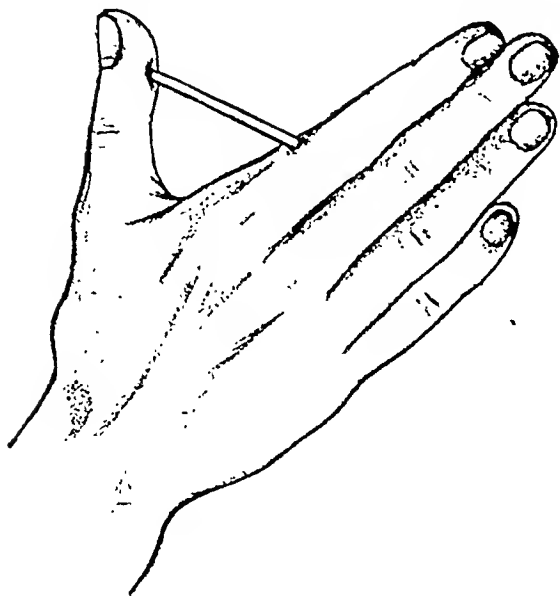


FIG. 2. The test, as described in the text, is performed by asking the patient to attempt adduction of the thumb, such adduction being prevented by a match held between the thumb and index finger.

anteriorly by the other short muscles of the thumb. It is obvious that the diagnosis, therefore, must be one of inference.

The clinical picture of swelling, pain, tenderness, pain on motion of the thumb and broadening of the web space between the thumb and index finger is suspicious of the presence of the lesion. However, it is a matter of clinical fact that this same syndrome may be presented by any tense inflammatory edema, e. g., cellulitis or lymphangitis, involving the base of the thumb. The diagnosis is made still more complex when the infection is a combined form, a not infrequent finding.

In an endeavor to add more accuracy to the clinical diagnosis of this condition,

existing either alone or in association with other inflammatory lesions of the hand, the following test was devised:

The patient's hand is placed palm downward on a flat surface to avoid use of the opponens muscle. An object is placed between the thumb and index finger of such size that approximately equals the natural distance between them. For this purpose an ordinary kitchen match is convenient and satisfactory, and can be easily broken into the desired length. The patient is asked to attempt approximation of the thumb to the index finger by pressing against the end of the match. This action is effected by the contraction of the adductor pollicis alone. If the muscle is overlain by pus, contraction of the muscle will cause pain in the base of the thumb. This pain occurs whether there is or is not actual motion of the metacarpal. In this test, practically no motion occurs, thus avoiding compression or stretching of the other soft tissues of the thumb base. In this way, the adductor pollicis and its overlying fascia is tested as a separate structure. The tender tissues of a lymphangitis or a cellulitis will undergo practically no stimulation during the test, and if either of these conditions is present without concomitant thenar space infection, the pain, so agonizing in intensity with thenar space abscess, will be either absent or minimal. (Fig. 2.)

In six cases of thenar space abscess, proven by operative findings, this test has been consistently positive. In no patient in which this test has failed to provide the expected results has there been subsequent demonstration of thenar space infection.



Case Reports

CARCINOMA OF THE CECUM IN ASSOCIATION WITH ACUTE APPENDICITIS

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THE finding of cecal malignancy in conjunction with acute appendicitis is unusual. It is true that cancer of the cecum often gives rise to symptoms suggesting "chronic appendicitis" and less often simulates the picture of acute appendicitis, but the definite association of the two conditions in an intimate pathological relationship has been demonstrated very infrequently. On the other hand, considering simply the mechanics which are involved, one would not expect the association of these two conditions to be so rare. Yet, it is, and in four representative studies¹⁻⁴ of malignancies of the cecum and ascending colon, no instances of the co-existence of malignancy and acute appendicitis are recorded. Erdman and Clark¹ studied forty-eight cases of cecal malignancy and do not mention the finding of acute appendicitis at all. Lahey² reviewed the cases at his clinic in 1939 and mentions no such association. Chamberlain³ studied forty-one cases of cecal carcinoma with no accompanying appendiceal inflammation and Mayo and Lovelace⁴ went over the 885 case histories of all the cecal and ascending colon malignancies at the Mayo Clinic for the period 1907 and 1938, and described no instance of intimate relationship between the growths and inflammation of the vermiform appendix.

Repeatedly, Charles W. Mayo has stressed in talks and in articles the necessity for examining the cecum at the time of appendectomy. He lays particular stress upon those cases in which the appendix is removed in an "interval stage" or where

it is found to be not acutely inflamed. A certain number of patients having had such operations show up with carcinoma of the cecum within a relatively short time afterwards, and the conclusion is obvious that the operator at the time of the appendectomy failed to evaluate carefully the cecum and ascending colon. It is our belief that a similar checkup should be made when one finds acute appendicitis especially if there be any suggestion of a mass present in the lower cecum. It is not advocated that the patient be subjected to an intra-abdominal exploration which would tend to spread contamination from the obviously inflamed appendix but it is urged that the available portion of the cecum be carefully scrutinized and palpated and the biopsies be taken as indicated. With the belief that more malignancies of the cecum could be found even in association with acute appendicitis, it is considered worth while airing this general subject at the present time.

The association of cecal malignancy and acute appendicitis has appeared as a subject entity in the literature but the writings on this association of pathologies is scant and spotty and seems worthy of review and correlation. One more case is reported here and added to the small total. A discussion of the subject is included covering the associated pathologies, the possibility of preoperative suspicion and the problem of diagnosis at operation. The question of what is proper treatment and when it should be instituted is also covered.

While Beran⁵ reported a case of cancer of the cecum associated with appendiceal

abscess in 1919, it was really Morton, of England, who first entered into a discussion of the whole problem.⁶ In a case report by Muir,⁷ obstruction by a cecal cancer caused appendiceal inflammation and mucocoele formation. Quoting from what may have been a personal communication (since the reference could not be traced), Muir writes as follows: "Wilkie has pointed out that acute appendicitis may be the first indication of this disease (carcinoma of the cecum)." Mayer⁸ reported three cases of acute appendicitis in association with bowel malignancy, one of which followed the course more typical of those in other reports. Parker and Rosenthal,⁹ cite one typical case of cecal carcinoma and acute appendicitis in which the carcinoma of the cecum invaded and obstructed the base of the appendix, giving an obstructive gangrenous appendicitis with rupture for which operation was performed and drainage instituted. The draining sinus persisted and the malignancy spread to and involved the ileocecal valve giving rise to a subsequent obstruction. Secondary operation revealed the true status of the conditions present. Another case is also reported which was almost identical with one of those reported by Mayer. It was one in which acute appendicitis was found in conjunction with an obstructing malignancy of the transverse colon. As late as 1935, Banks and Green¹⁰ made the statement that in the literature they were able to find but three papers on this subject, the one by Mayer, the one by Parker and Rosenthal and another by a French author named Shears¹¹ whose article is not available to this writer. The immediate authors add another case of their own. Also in 1936, Cooke¹² reports one more case which is a rather typical one. The patient had an acute episode of abdominal pain and was found to have an abscess in the appendiceal area. This was drained and continued to drain for a period of eight months. At this time a mass was palpable and the patient was re-operated upon. The appendix was apparently completely digested for it was not found at the

second operation; a cancer of the cecum was present, however. The involved tissue was removed and an ileotransverse colostomy done. A local recurrence was noted a year and one-quarter later in the abdominal wall at the site of the sinus tract. In 1938, Seegers¹³ reported three cases of carcinoma of the cecum, their clinical course resembling that of appendicitis and in the same year Speese and Bothe¹⁴ reported two cases; the one case showed a rather typical association of acute appendicitis plus cecal carcinoma but in the other, no acute appendicitis was found, although there was every preoperative indication that it was present. The subject was again discussed in an article by Bartlett and Miller¹⁵ in which acute appendicitis is regarded as a "complication" of carcinoma of the cecum.

Three excellent references which have a bearing on one aspect of the subject, namely, the question as to whether carcinoma at the base of the appendix is cecal or appendiceal, are given as follows: Young and Wyman,¹⁶ Uihlein and McDonald,¹⁷ and Chomet.¹⁸

Throughout the scant literature on this subject, there appears to be a few common denominators: (1) An acute attack suggesting appendicitis in an individual in whom no suspicion of malignancy exists; (2) abscess formation in the appendiceal region; (3) failure to identify the presence of a neoplasm at the primary operation; (4) a persistence of the draining sinus beyond normal expectancy, and (5) the feeling of a mass near the lower cecum.

Sifting out of the case reports those in which the malignancy was further along in the large bowel than the cecum or in which there was some other reason to doubt that the intimate association of cecal cancer and acute appendicitis existed there remain eleven instances of this association. The articles by Wilkie (as quoted by Muir⁷) and Shears¹¹ were not available.

CASE REPORT

A twenty-three-year old, white male first noticed abdominal pain June 10, 1944. This



FIG. 1. X-ray taken September 1, 1944, showing what appears to be extrinsic pressure upon the lower portion of the cecum and adjacent small bowel, giving a distorted outline of these parts. In the center of the infringing mass is a small calcified area.



FIG. 2. A later appearance of the bowel on the same day, September 1, 1944, showing the persistence of the deformity in the lower cecum and adjacent bowel, apparently from extrinsic pressure. One shadow in the small bowel seems to demonstrate the Meckel's diverticulum unsuspected at this time but later found at operation.

centered at first in the lower abdomen just below the umbilicus but moved very promptly to the right lower quadrant and remained as a sharp, steady, moderately severe pain until the night of June 12, 1944, when the pain was so severe it interfered with sleep. On the next day the patient was hospitalized. The pain did not radiate although the patient occasionally felt an isolated sharp twinge in the region of the heart on deep breathing. There had been loss of appetite and slight nausea since the onset of pain but no vomiting. The bowels moved daily and stools were well formed. There was no dysuria.

The patient enjoyed good health previously except for an alleged attack of appendicitis in childhood. The family and social history contributed nothing.

Physical findings on abdominal examination were described by the examiner as follows: "There is moderate tenderness in the right lower quadrant about at McBurney's point and there is a smooth, rounded, tender mass

palpable in the right lower quadrant. Rebound tenderness is referred to the right lower quadrant."

The diagnosis of an acute appendicitis was made and on June 13, 1944, the day of admission, and the patient was operated upon. The operative note is as follows: "Abdomen was prepared with Tincture of Merthiolate, opened through McBurney incision. There was a small amount of clear fluid present. The cecum could not be delivered. The appendix could be palpated lying retroceally and felt to be 2 cm. in diameter by about 7 cm. in length. The organ was entirely retroperitoneal, not even a trace being visible. An attempt was made to mobilize the cecum and expose the appendix but the tissues were so acutely infected and so friable that it was felt to be better judgment simply to drain the appendiceal region. Drainage was established with cigarette drains, one in the pelvis, one in the lateral gutter, one in the retrocecal portion, where mobilization had



FIG. 3. Photograph of specimen unopened showing mostly the numerous adhesions of the small bowel to the cecum, the fullness of the lower end of the cecum and the absence of any remains of the appendix. Meckel's diverticulum is clearly shown.

been started. Wound closed about the drain in layers."

The operation lasted one hour nine minutes. Anesthesia was a spinal, 150 mg. of procaine hydrochloride being administered.

The patient's recovery after operation was prompt and his general condition was good. Drains were removed on the fifth day. As his convalescence progressed, he complained of continued pain in the lower right quadrant and a palpable mass was still extant there. The draining sinus persisted. This status continued for approximately two and one-half months when he was transferred to this hospital.

Upon examination here, the patient was found to be in excellent general condition and the only positive findings were the scar of his previous operation, a draining sinus within it and a palpable mass deep in the lower right quadrant beneath the scar. This mass was firm and seemed to be fixed to the undersurface of the abdominal wall.

Laboratory examinations gave findings within normal limits including hemoglobin values, ethrocyte counts and urinalyses.

X-ray of the gastrointestinal tract (Figs. 1 and 2) was reported as follows: "... Subse-

quent observation at 2, 3, and 4 hours shows a filling defect from what appears to be an extrinsic lesion in the right lower quadrant. This displaces the cecum and terminal ileum upward and 2 or 3 other loops of ileum medialward. In the center of this defect is a small irregular oval shadow about 1.5 cm. having the density of calcium. This may possibly represent a foreign body reaction. Impression: Chronic granuloma in the region of the cecum."

It was believed that the patient had an ample opportunity to heal his sinus tract. The possibility that it was being perpetuated by some foreign body at the base of the tract was taken into consideration and a decision was made to open the abdomen and investigate. This was done on September 4, 1944. The operative report of this procedure reads as follows: "A four-inch right rectus incision was made, centered $1\frac{1}{2}$ inches below the umbilicus and $1\frac{1}{2}$ inches to the right of it. On opening the peritoneal cavity, the cecum was found to be tightly bound to the lateral and posterolateral abdominal wall. Loops of small bowel were attached to the cecum by recent but well established adhesions. These adhesions were severed and the small bowel separated from



FIG. 4. Cecum open shows the malignant mass to be at the lower portion of the cecum near where the appendix presumably joined it.

the cecum. It was impossible to bring the cecum up without breaking into the chronic inflammatory fibrous tissue which bound it to the abdominal wall. Separation of the cecum from the parietes was begun and carried on gradually. Very firm and even calcareous fibrous and chronic inflammatory tissue was encountered. Pieces of this very firm tissue were taken for microscopic examination. The cecum was not opened during the freeing process but its undersurface was quite raw when it was finally dislodged. No remains of the appendix could be identified despite the fact that the area where it might be expected was well exposed. The raw surface of the cecal wall was closed over with 'oo' plain catgut sutures. A cigarette drain was placed in the operative area and brought out through the lower angle of the wound. The abdomen was then closed in layers."

Following this operation the patient had a somewhat stormy convalescence with drainage from the new wound. He gradually improved, however, and after approximately four weeks, the draining sinus had healed over as had also the original sinus.

The report from the pathologist on the sections submitted was most interesting. "Histology: Histological examination of wall of specimen sent in from the operation reveals an infiltration in all of alveolar gland composed of a single layer of columnar epithelium resembling intestinal mucosa. They are grow-

ing without a definite pattern in a connective tissue stroma which is infiltrated with lymphocytes. Although this represents a definite malignancy, it is of low grade pathologically since the alveolar structure is well maintained throughout. Some of the glands secrete mucous. Diagnosis: Adenocarcinoma of intestine, probably colon."

On the basis of these findings another operation was unquestionably necessary. Some time was allowed for further convalescence and general up-building and included a furlough home since the man's morale was somewhat low. This delayed the direct action upon the malignant growth but it was time well spent for when the patient returned he was in good spirits, had gained weight and the abdominal wall was free of any residual infection. The preoperative checkup revealed normal findings for blood count, hemoglobin, plasma protein level and blood chemistry. The bowels moved normally every day and he never had any indication of change in bowel habit nor had blood ever been detected in the stools.

On November 16, 1944, (five months after the first admission for "acute appendicitis") a third operation was performed. The description follows: "With the patient under anesthesia, palpation of the abdominal wall and through it the abdomen itself revealed a mass in the lower right quadrant approximately 2" X 3" in measurement. This was firm and fixed. The abdomen was opened through the

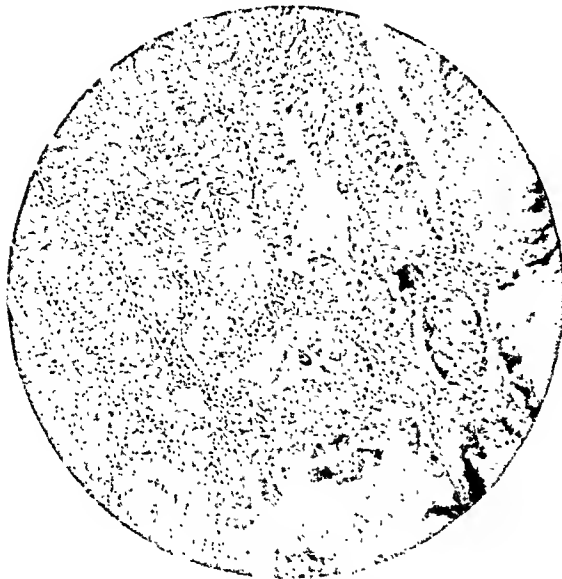


FIG. 5. Microphotograph ($\times 125$) represents the more adenoid portion of the tumor showing irregular large mucus-secreting glands with some loss of polarity of nuclei and piling of cylindrical epithelial cells. Some of the tubules show cystic distention.

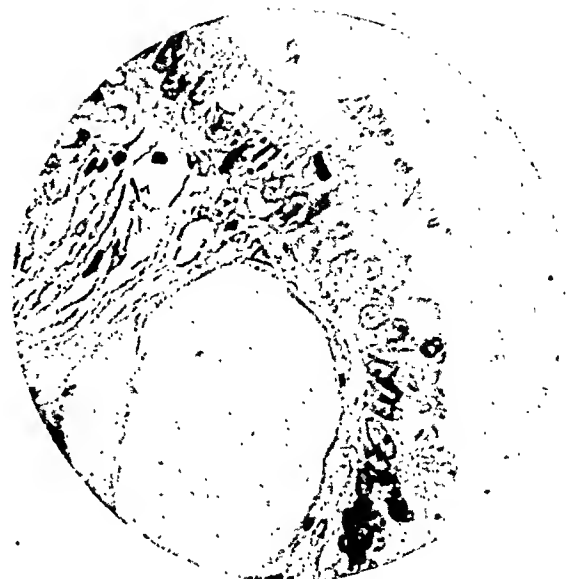


FIG. 6. Microphotograph ($\times 600$) shows typical secreting cylindrical cells that line some spaces; the dark band-like nucleus (indicated by arrow) is a mitotic figure removed from normal position against the basement membrane. Other space filled with thin mucin has lost its epithelial lining.

previous right rectus incision and after omental adhesions were freed, the bowel in the lower right quadrant was seen to be tightly bound down. Hard tissue was palpated in the region of the lower cecum and in the mesentery nearby, nodules were felt. Small loops of bowel bound in the mass were freed and the mass seemed to involve the cecum. This was fixed to the adjacent structures and separately to the anterolateral abdominal wall. The liver was examined and found to be normal; there were no nodules in it. Firm and hard glands were present in the mesentery, both adjacent to the mass and beyond the immediate vicinity of the same. The cecum with its contained mass was gradually freed from the tissues in contact with it. The process of freeing was a tedious one and it was impossible to separate the mass completely from the posterolateral peritoneum and abdominal wall. In order to mobilize the cecum, the peritoneum and part of the muscle tissue of the abdominal wall was incised in an encircling manner and brought away with the mass. Elevating the lower portion of the cecum, the iliac vessels and ureter were separated from it. The small bowel proximal to the cecum was traced backward and a Meckle's diverticulum found bound deep in the pelvis. Going distally from the mass, the ascending colon seemed free of involvement in

its upper portion. The bowel was divided through the transverse colon near the hepatic flexure and again approximately 4' proximal to the ileocecal junction. The portion between, including the mass, was removed. Both ends of the bowel were closed in and a side-to-side ileotransverse colostomy done. Prior to the anastomosis all suspicious glands were dissected out and that portion of the abdominal wall which was about the old sinus tract leading down to the mass was excised in toto. Sulfanilamide powder was dusted onto the bowel. A cigarette drain was placed in the area and brought out through the opening made by the excision of the sinus tract. The abdominal wounds were closed by through-and-through sutures of #10 crochet cotton."

For a day or two there was some drainage of serum and blood from the wound but the patient's recovery was rapid and most satisfactory. He was passing gas within five days and had a bowel movement on the seventh day. Both abdominal wounds were completely healed within two weeks.

A report on the tissue examination dated November 30, 1944, reads as follows: "There is a large Meckle's diverticulum 6 cm. in length and 2 cm. in diameter. This shows no inflammation or ulceration. A portion of the ileum is adherent to the cecum by old adhesions and in

intimate contact with a large tumor mass the size of a small apple. (Fig. 3.) On the serosal side it is covered by a fibrous tissue adhesion. On the mucosa side it shows two fungating protrusions into the lumen measuring each approximately 3 cm. in diameter. (Fig. 4.) The section through the tumor mass reveals it to lie in the mucosa and submucosa. However, section into the mass of fibrous tissues by which the ileum is bound to the cecum reveals an infiltration of malignant tissue throughout this area. Tumor is somewhat gelatinous on section suggesting colloid type of malignancy. There are four regional lymph nodes included with the specimen. Only one of these is enlarged and is found to contain a dense white indurated tissue resembling malignant tissue. The others also show this same type of tissue. There are no implants of carcinomatous tissue visible on the free portions of the ileum or its mesentery. Histology: Histological examination of the mass and the regional lymph nodes reveals a similar picture in each. In a fibrous stroma infiltrated with lymphocytes, there is a growth of atypical glands lined by columnar epithelial cells. These show pleomorphism and mitotic figures. Atypical large round cells with rounded eccentric nuclei characteristic of colloid type of adenocarcinoma are also seen and atypical gland spaces are filling with stringy basophilic mucus. Diagnosis: Colloid adenocarcinoma of the cecum with metastasis to regional lymphnodes." (Figs. 5 and 6.)

The soldier made a complete recovery from this operation and was soon able to eat a regular house meal. His bowels moved daily and he gained weight. X-ray examination of the bones and chest showed no evidence of any spread of the malignancy and after a two months' convalescence, he was discharged.

COMMENT

The discussion may be introduced by quoting from the article by Uihlein and McDonald¹⁷ in which they describe three types of carcinoma of the appendix, the last of which is that type "which resembles both grossly and microscopically those found in the colon and which will be referred to as the colonic type." Speaking further of this colonic type of appendiceal carcinoma they state, "Because of their



FIG. 7. This microphotograph shows tumor infiltrating the skin. Skin is to the right; tubules of tumor cells seen invading dermal papilla via lymphatics. In derma and subcutaneous area to the left are spaces filled with mucus; occasionally, a tubule of tumor was seen and in some of the smaller spaces are loosened islands of secreting tumor epithelial cells.

frequent location in the base of the appendix, obstruction to the appendiceal lumen usually results early in the course of the disease. As a consequence, acute appendicitis usually with perforation is a common occurrence." While the cases which are under discussion in this paper are not carcinomas of the appendix, still the location of a carcinoma in the cecum in many instances will result in the same mechanical blockage of the lumen of the appendix, either by direct impingement or by the impingement of secondary inflammatory swelling. One other point should be mentioned in the possible etiology of acute appendicitis and that is the rôle of infection. Should the surface of the carcinoma become eroded, certainly an entrance is furnished for bacteria which may make their way to the tissues in the walls of the adjacent appendix and thus contribute to if not precipitate the attack of acute appendicitis. In any event the most likely possibility as far as the carcinoma precipitating an attack of acute appendicitis goes, is the one of obstruction of the appendiceal lu-

men. It is not entirely out of the realm of possibility, however, that a certain number of these patients simply develop simultaneously an attack of acute appendicitis in the presence of a carcinoma in the adjoining cecum.

An interesting sidelight and again possibly explained by blockage of the appendiceal lumen by the growth or its attendant inflammation, is the fact that certainly in one case as described by Speese and Bothe,¹⁴ a carcinoma of the cecum may give convincing signs and symptoms of acute appendicitis when none is actually present. The convincing picture in a case like this could undoubtedly be due to a temporary distention of the appendiceal lumen with retained gas without the organ actually going on to a state of inflammation.

In our own case, the proximity of the growth to the appendiceal lumen certainly suggested obstruction as the underlying etiological factor.

As to diagnosis, it is almost impossible to diagnose the presence of the two lesions preoperatively. If the attack were to come on in a patient with preceding classical signs and symptoms of a malignancy in the cecum, it might be possible to arrive at an accurate diagnosis. Usually these co-lesions have occurred in rather young individuals in whom the presence of a malignancy has not been suspected. Diagnosis with the abdomen opened is difficult enough in the presence of the acute inflammation in and about a gangrenous appendix. In the case here cited the appendix was apparently thick, acutely inflamed and completely retrocecal and the picture very confusing. It is very difficult to tell whether the swelling and firmness in the adjacent structure of the cecum is due to a neoplasm or whether it is simply a continuity of an inflammatory reaction. If the presence of malignancy is suspected, certainly a biopsy of nodes, appendages or even possibly of the bowel wall itself is indicated. Should an abscess be present, the diagnosis is even more difficult, for the operator feels restricted in his investiga-

tions within the abdomen. In cases of longer standing, the clue is the persistence of the drainage and the chronicity of the sinus tract; also as in our own case, the presence of a mass may be detected later deep within the abdomen usually at the base of the sinus tract. Even with this picture it must be recognized that sinuses following appendiceal abscesses in which the appendix or part of it is allowed to remain in the belly, persist for a long, long time whether a cancer be there or not. One is faced with the decision as to whether he should or should not open the abdomen to investigate the situation and again when such investigation is most desirable. Certainly, a period of time should be allowed to elapse in order to permit what infection is present to become as innocuous as possible. Upon this secondary investigation one may not be able to tell grossly that he is dealing with a malignant mass, as was true here. Again, in this present case the presence of a calcification suggested very strongly a marked chronic inflammatory reaction which undoubtedly was also present, but in addition, the patient had a malignancy of the cecum. Frozen sections would be of great help in such contingencies.

As far as the operative treatment goes, two fundamental things need to be done: First, the involved bowel and adjacent lymph nodes should be removed as completely as possible and bowel continuity restored. In the second place, the contact portion of the abdominal wall plus the tissue surrounding the sinus tract should be removed *en bloc*. The need for this is well demonstrated in our present case in which sections taken from along the sinus tract showed a creeping towards the surface of the malignant epithelium. (Fig. 7.) Unless one is dealing with a badly infected area, the one-stage ileotransverse colostomy, following the removal of the involved portion of the bowel, is desirable.

SUMMARY

1. The literature on the subject of carcinoma of the cecum in association with

ute appendicitis has been reviewed and a total of eleven cases found therein. One more case is added.

2. The common succession of events is:

(1) Signs and symptoms of acute appendicitis in an individual unsuspected of harboring a malignancy; (2) appendiceal rupture and abscess formation; (3) drainage of the abscess without recognition of the presence of cecal cancer; (4) failure of the resulting sinus to close, and (5) the feeling of a mass in relation to the lower end of the cecum.

3. Diagnosis preoperatively is almost impossible. Diagnosis at operation rests on suspecting the possibility of the presence of a growth, carefully examining and evaluating the available portion of cecum and finally taking tissue for microscopic examination when indicated.

4. Resection of the affected portion of bowel, the tissue in the "contact" part of the abdominal wall and the tissue surrounding the sinus tract should be done. A primary ileotransverse colostomy restores bowel continuity.

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EMBRYONAL TUMORS OF KIDNEY IN INFANCY AND CHILDHOOD

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RENAL tumors were known to surgeons for a long time. Koenig attempted to classify them as early as 1826. Rathery, in 1870, called attention to the fact that the kidney was the organ most frequently affected by malignant disease in infancy. Jacobi, in 1884, demonstrated the frequency of these tumors and studied their typical structure and demonstrated their presence at birth. Ewing¹ states that it is rare after the tenth year and is usually found in the first three years. It has been found to be responsible for the largest percentage of malignancy in infancy and its large size has been reported as a cause of dystocia. A more complete review of the history of renal tumors may be had by reference to articles by Kretschmer² and Gilbert.³

Kidney tumors may be divided according to their histological structure and according to the character of the growth of the tumors into three groups: (1) *Benign*: lipoma, chondroma, osteoma, fibro-adenoma; (2) *malignant*: sarcoma, adenosarcoma, adenomyosarcoma, teratoma and sarcocarcinoma, and (3) *cysts*: congenital cystic kidney, hydronephrosis, pyonephrosis and ecchinoccal cysts of kidney.

Many attempts have been made to give a satisfactory explanation of these curious tumors. Some do not explain all the features and some contradict each other. Wilms¹⁵ supposed that undifferentiated germs of mesoderm were deposited in the primitive kidney at a very early period of embryonal life where they acted as a matrix for composite tumors composed of various tissue elements. Dean and Pack⁴ have given an excellent review of the various theories. They concluded that (1) the tumor origi-

nates at different developmental periods of the embryo; (2) the renal blastoma or nephrotome is a predominating contributing structure, and a tumor anlage which establishes itself at this stage will elaborate tissue easily recognized as renal in origin; (3) in a tumor anlage which separates earlier, before the formation of the nephrotome, there is a larger number of possibilities for elaborating multiple tumor cells, which may account for the presence of muscle fibers and other tissues in the tumor.

Pathology. The tumors vary greatly in size. They have been reported to be as large as 5,000 Gm.; one case was reported in which the distended abdomen extended down to the knees. The tumors are predominantly unilateral (85 to 90 per cent), encapsulated, retroperitoneal and arise within the kidney capsule. The kidney takes no part in the tumor formation and usually there is a layer of fibrous tissue between the neoplasm and the atrophied kidney which is reduced to a shell. The tumors are usually of a hard elastic consistency, smooth, irregular and non-fluctuating. There may be areas of necrosis in different parts (usually at the areas of most rapid growth). Due to various tissue elements present, the cut surface will reveal areas where different cells are in preponderance. The blood supply is usually extremely rich and it is not uncommon to see many blood sinuses throughout the tumor.

Histologically, the most striking feature is the embryonal character of the cells. The tumor is in true sense a mixed tumor, the usual cells found being composed of epithelial, fibroblastic and smooth muscle cells. Other cells that have been reported are striated muscle, cartilage and bone. A

great many varieties of arrangement of the above elements have been reported. The cells are usually of cuboidal or cylindrical character arranged about a lumen, so as to resemble an abortive renal tubule. Between these are usually seen strands or sheets of fibroblastic cells among which may be found groups of smooth muscle cells, striated muscle, cartilage and in rare cases, bone.¹

Clinical Symptoms and Findings. The outstanding feature is the presence of an extremely rapidly growing mass and in the majority of cases this is the only thing noticed until late in the disease when loss of weight, digestive disturbances and pain make their appearance. The mass is usually hard, smooth, non-fluctuating and freely movable. The enlargement is the first symptom in about 85 per cent of cases; while in adults the enlargement is the first symptom in only 23 per cent of cases. Pain is very rare in children (about 7 to 8 per cent) while in adults it often is the first symptom. Pain, when found, is usually in the back and loins.

Hematuria, casts and albumin are usually the last findings, when they do occur, for in over 50 per cent of the reported cases, repeated urine examinations were negative to the end. This is also a differentiating factor between tumors of children and adults, for in adults it is practically a constant finding.

The general well being of the patient is usually very slightly or not at all affected in the beginning. It is not until the end of the illness that there is a rapid loss of weight; red cells and hemoglobin rapidly go down and cachexia ensues. At this time digestive disturbances set in, varying from nausea to severe vomiting with no retention of any food. There usually is constipation to obstipation, but it is not uncommon to see severe diarrheas with extremely foul greenish stools.

Diagnosis. These tumors are not diagnosed any earlier or more frequently today than they were forty years ago. General clinical examination, the history, and

physical examination lead to their recognition. There are no early symptoms. The classical triad of hemorrhage, pain and tumor is of no value in children, for as previously pointed out, the cardinal feature is only the rapidly growing mass. In the differential diagnosis the following are to be considered.

An enlarged spleen may be recognized by its general form, the more anterior position, the greater mobility, its displacement by respiration; probable alteration of the blood picture may facilitate diagnosis.

A liver tumor can often be differentiated by its relationship to the lower border of the lung, possible jaundice and functional tests.

In acute cases of hydro- and pyonephrosis the sudden onset with collapse, high fever, etc., through torsion will help us, while in the slower cases of compression or stricture, a round fluctuating mass is found.

Cystic kidney is as a rule bilateral with lobulated surface. Large tumors of this type are not seen for they cause death.

Ecchinococic cysts are diagnosed easily if perforation of the urinary tract takes place and hooklets or daughter cysts are found. Eosinophilia is of value if over 7 per cent and intestinal parasites can be excluded.

Adrenal tumors (neuroblastomas) are only recognizable as such if they give the typical metastases in the liver (Pepper type) or in the skull with orbital hemorrhages (Hutchinson type).

Enlarged mesenteric glands are generally found in the median line; malignant tumors are smaller, harder and more nodular.

Tubercular growths are seen more in the lower abdomen and usually lie transversely.

Peritoneal cysts are fluctuating, more movable and not so large in size.

Ovarian cysts as a rule can always have their connection with the uterus ascertained and patients are sometimes subject to precocious menstruation.

Psoas abscesses are most easily palpable above the inguinal ligament and have an oblong shape. They cause a typical position

of the leg and extension of the thigh is painful.

Considering all of the above, a diagnosis is still impossible many times without an exploratory laparotomy. The laparotomy is advisable for no matter how difficult the diagnosis may be, the treatment is most certainly even more so.

Prognosis. Prognosis is indeed very poor with figures by McNeill and Chilko⁵ well over 90 per cent in a series of 383 cases. In smaller series of cases it was 100 per cent as in Bothe's series of seven cases.⁶

Treatment. Because of the varied structure of the tumor, depending upon the developmental period of the embryo when it took origin, the rate of growth and response to various kinds of treatment, treatment is greatly variant. The time in the disease that consultation is sought and the patient's condition also play a great part. The rapidity with which metastases have been seen to occur in patients under observation is another deciding factor.⁷ There have been, as a result, various methods of treatment instituted by different men. Ladd and White,⁸ in reviewing sixty cases, stress immediate surgery as soon as the diagnosis is made. They advise immediate surgery because during the time that is required for preoperative radiation and the waiting period for surgery, the chance for metastasis by way of the blood stream is very good. They are of the opinion that if the patient is adequately prepared physiologically, the operative mortality is negligible; that the tumor should be approached by the transperitoneal route so that the renal vessels may be ligated first, thus preventing dissemination of viable tumor cells. They also are of the opinion that preoperative radiation for shrinkage of the tumor may force malignant cells into the blood stream. Of the sixty so managed, fourteen were probably cured and in four the operations were too recent to form any conclusions.

Dean⁷ employed radiation alone in twenty cases in the past fifteen years and reports that five of the patients are living

without any evidence of metastases five or more years after treatment. Although this is a high percentage of cures, he does not recommend this procedure because even in the most radio-sensitive cases it probably requires many months to devitalize the tumor completely, and during this time metastasis can take place. He reserves exclusive radiation for those cases that present metastatic lesions already present, believing that at that stage surgery has nothing to offer.

Randal⁹ stresses the advantages of preoperative irradiation over postoperative irradiation, pointing out that recurrences after irradiation exhibit increased resistance to this form of therapy and ultimately the new growth exceeds irradiative destruction, i.e., becomes "fast" to any type of irradiation. He also considered the importance that preoperative irradiation include the chest and abdomen in order to attempt creation of an infertile field for metastatic transplants that may be dislodged by the handling of the tumor at extirpation.

Kerr and Stephens¹⁰ also stressed the use of irradiation preoperatively as being of great value, concluding that it appears that on those operable cases, preoperative roentgen therapy improves the prognosis while postoperative therapy apparently has nothing more to offer than surgical removal without irradiation.

Priestley and Broders,¹¹ in their review of sixty-five cases of Wilm's tumor, conclude that preoperative irradiation followed in three to six weeks by nephrectomy with extensive postoperative irradiation was the treatment of choice.

Soloway,¹² Bixler, Stenstrom and Creevy¹³ and Rowe and Frazer¹⁴ are also of the opinion that pre- and postoperative irradiation should be used and constitute the methods of choice.

The various methods of treatment for Wilm's tumor may be summarized as: (1) surgery alone, (2) radiation therapy alone, (3) surgery with preoperative radiation, (4) surgery with postoperative radiation,

and (5) surgery with preoperative and postoperative radiation. The results of treatment by various methods in thirteen different series of cases is given by Bixler, Stenstrom and Creevy.¹³ The final answer will come with further study in the publications of the future. Results, as a whole, are poor regardless of the method of therapy instituted.

CASE REPORT

J. M., a male infant, seven and a half months of age, was admitted to the Norwegian Hospital with a complaint of a rapidly growing abdominal mass. The mother first noticed a rather large, hard mass in the right upper quadrant about three weeks prior to admission. She stated that at first the mass seemed tender, but after a few days the baby did not mind pressure over the mass. Except for being slightly restless at night, the mother claimed the baby had not appeared to be sick, though she thought it might have had a little fever at night. The baby had been breast fed until one week prior to admission, when he was put on a formula. Stools were normal, but after being given the formula they became loose and very soft. At times the mother had noticed curds and mucus in stool, but no blood. The baby was full term at delivery. Delivery was by low forceps but otherwise uneventful. The baby progressed very well, taking breast as mentioned and ate cereals, vegetables, eggs, apple-sauce and other baby foods which were all well tolerated. He had taken cod liver oil and orange juice daily. The family history revealed nothing of a contributory nature. Physical examination revealed a well nourished, well developed male infant about seven and a half months old, resting comfortably in bed, with no evidence of any distress; hemic component was good, respirations normal, there was no dehydration, eruptions or evidence of any acute illness. Detailed physical examination revealed nothing of note except the abdomen, which was of irregular contour with an enlargement in right upper quadrant. The skin was tense and there were a few prominent veins visible over the enlargement. The mass extended out to the flank and back and downward to the umbilicus. It was hard, smooth and globular in shape. The mass was distinct from the liver and was freely movable. Percussion note over

the mass was flat. No fluid wave was elicited. The mass was apparently the kidney. The left kidney was not palpable, nor was the spleen.

Urine examination on admission revealed it to be straw-colored, clear, with an acid reaction, specific gravity 1020, with a trace of albumin, few uric acid crystals with no white or red blood cells. Blood count on admission: red blood count, 4,300,000; hemoglobin 85 per cent; white blood count 12,700, neutrophils 73 per cent, lymphocytes 25 per cent, endothelial 2 per cent. Stool examination on admission showed a slight amount of mucus but no blood or parasites. X-ray examination revealed a large opaque mass occupying the entire right upper quadrant of the abdomen. Skull, lungs, spine and long bones revealed no evidence of metastases.

Diagnosis of neoplasm of right kidney, probably Wilm's tumor, was made and nephrectomy was performed by the transperitoneal route. No special difficulties were encountered and infant withstood the operation very well. The mass was retroperitoneal and about five to six inches in diameter, more or less globular in shape. It displaced the liver upward and the transverse and ascending colons toward the midline. The kidney itself was thinned out and reduced to a mere shell. Microscopic section showed two types of tissues, fibrous and epithelial. The fibrous tissue was dense and stained very deeply. Section showed spaces lined with what appeared to be papillae undergoing fibrous replacement. The epithelial cells were cylindrical in type and arranged in a heterogenous glandular arrangement, surrounded by loosely woven, but very cellular connective tissue. There were several areas of necrosis and hemorrhage in the epithelial portion. Pathologic diagnosis was: Embryoma of right kidney.

The infant made an uneventful recovery and was discharged from the hospital exactly two weeks following operation. The infant progressed very well, gaining weight, etc. Two weeks later, infant began to receive irradiation with the thought in mind of preventing metastasis. However, one month following discharge from hospital a small mass in the left kidney area made itself apparent to deep palpation. This mass grew very rapidly in the face of continued roentgen therapy and inside of one month had reached to almost the size of the original tumor on the right side. The baby's

condition during this month became steadily worse in spite of adequate supportive measures and finally, by the end of the month, the infant expired. Postmortem examination was refused by the family, but there is no doubt that the growth in the left kidney was of a metastatic nature and definitely associated with the original tumor.

SUMMARY AND CONCLUSIONS

1. Tumors occur within the first three years of life.
2. They are definitely embryonal in nature.
3. Development is independent of the kidney. The kidney itself does not take part in the growth, but undergoes atrophy and is reduced to a shell.
4. Growth is extremely rapid, producing tumors of enormous size, and they are usually unilateral.
5. Associated symptoms are few and occur late.
6. Various methods of treatment and management are stressed.

7. A case report is presented.

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A MODIFIED WHIPPLE OPERATION FOR CARCINOMA AT THE AMPULLA OF VATER*

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SINCE 1935, when Whipple, Parsons and Mullins advocated their technic for the radical removal of carcinoma of the ampulla of Vater and the head of the pancreas, numerous modifications have been proposed. The original operation was performed in two stages. In the first stage the common duct was ligated and a cholecystojejunostomy was performed. In the second stage the lesion was removed and a gastrojejunostomy performed. Whipple now completes the operation in one stage. Orr's modification consisted in performing an operation in two stages. In the first stage a choledochogastrostomy and a posterior gastrostomy were completed. In the second stage he removed the head of the pancreas with the duodenum. Horsley operated upon a patient for carcinoma of the ampulla of Vater, which histologically proved to be a benign growth. After the removal of this lesion with the duodenum and head of the pancreas he implanted the common duct into the open end of the duodenum. The pancreas was also included in this anastomosis. In another case in which the gallbladder had been removed, Hunt performed a choledochojejunostomy. The pancreas was implanted into the distal portion of the jejunum. Brunschwig performed the operation in two stages. In the first stage a cholecystojejunostomy and a posterior gastrojejunostomy were performed. In the second stage the diseased area was excised. The free end of the pancreas was oversewn. Hunt and Trimble then advocated a one-stage operation with the common duct anastomosed to the jejunum with the aid of a

τ tube. The pancreas was inserted into the proximal end of the jejunum. In the operation as advocated by Trimble in one stage the same technic is used, except that the cut end of the pancreas is oversewn.

CASE REPORT

J. S., age forty-three, a female, was admitted to the Mt. Sinai Hospital on December 14, 1944, service of Dr. Abraham Trasoff, and she was discharged on February 3, 1945. Her chief complaint was jaundice for one year, bile stained urine and light stools. There was no weakness, nausea, vomiting or fever. At the outset of her symptoms the abdomen was enlarged due to gaseous distention. Eructations of gas were frequent. Pruritis was an annoying symptom. She lost ten or twelve pounds in weight. Her previous history and family history were unimportant.

A physical examination revealed a patient with generalized jaundice with slight rigidity in right upper quadrant of the abdomen. The icteric index at this time was 65. In the following few weeks after March 7, 1944, the jaundice decreased somewhat and the pruritis abated. Then for the following five months the jaundice and pruritis became more severe. She refused hospitalization at this time because she never had any abdominal pain. She came to the medical clinic on December 7, 1944, and was admitted to the hospital on December 14th. Blood pressure was 110/64. There was no edema or cyanosis. The sclera were stained a deep yellow. The tongue was very dry and there were small palpable lymphatic glands in the submaxillary areas. The heart was normal. There were no murmurs and the heart was not enlarged. There was no diminution of the breath sounds. Some impairment to percussion in both upper portions of the chest posteriorly was noted. The remainder of the chest was

* From the Service of Mt. Sinai Hospital, Philadelphia, Pa. Read before the South-Southeast Branches of The Philadelphia County Medical Society on March 20, 1945.

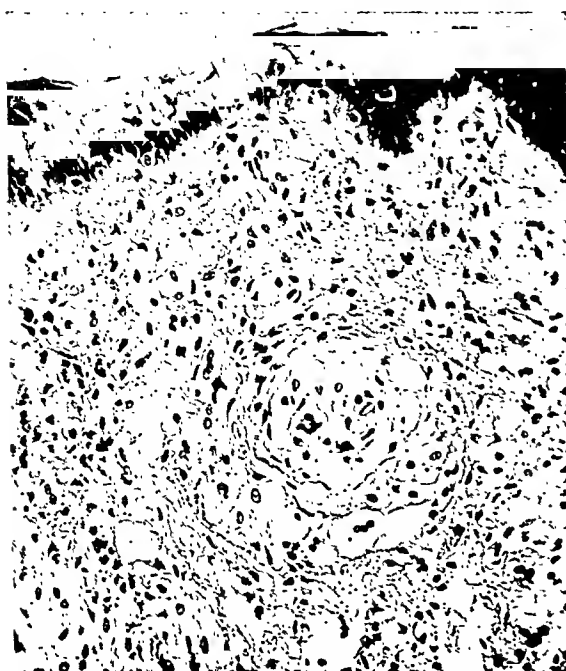


FIG. 1. Section of skin showing xanthomatous cells.

normal. No râles were present. The abdomen was soft without splenic enlargement. The area over the gallbladder was rigid. The liver was somewhat enlarged and could be felt below the umbilicus. The edge was irregular. The surface seemed smooth and not tender. The diagnosis at this time was carcinoma of the head of the pancreas with possible metastasis to the liver.

Laboratory findings were as follows: Urine reaction acid specific gravity 1005; protein ft., sugar negative; white blood cells 30-35; red blood cells occasionally; urobilinogen in urine 1.60 dilution; hemoglobin Gm. 8.7 per cent (62 per cent); red blood count 3,030,000; white blood count 10,700; seg. 67; non-seg. 6; lymphocytes 17; monocytes (trans.)—4; eosinophiles—6; platelets—220,000; fragility—0.48—0.30; prothrombin time 15 per cent; blood sugar 117. BUN 10.1; cholesterol 624—cholesterol esters 290—ratio 46 per cent. phosphorus—3.4; phosphatase—12.4 units; van den Bergh 4.8 mg. per cent; icteric index—124; hippuric acid test 2.2 Gm.; total proteins—6.4; benzoic acid—3.4 Gm. in four hours; cephalofluorescent flocc.—0. W. and K.—negative; serum amylase—205; U/100 cc. of serum.

On December 20th, I was called in consultation to give a surgical opinion. Physical examination revealed the liver to be very much enlarged. The gallbladder was also enlarged giving rise to Courvoisier's sign. The spleen could

not be palpated. The patient was jaundiced due to obstruction of the common duct as a result of carcinoma of the head of the pancreas.

On December 29th, a piece of skin was removed and sent to the laboratory for histological examination. Dr. D. Meranze, Director, reported that the specimen consisted of a piece of skin measuring 2.5 by 0.3 cm. The cut surface presented no unusual features. Under the microscope small aggregates of non-specific xanthomatous cells were present. The pathological diagnosis: skin xanthomatosis. (Fig. 1.) Six months after operation all evidence of skin xanthomatosis had disappeared. One year after operation revealed a normal condition of the skin body surface.

The findings at operation revealed a papillary carcinoma of the papilla of Vater (Fig. 2.), marked dilatation of the biliary system, hydrops of the gallbladder, biliary cirrhotic liver and marked enlargement of the liver.

On January 5, 1945, under fractional spinal anesthesia, the abdomen was prepared in the usual manner, and an upper right rectus incision was made through the peritoneum. All bleeding points were caught, clamped and ligated with plain No. 0 catgut. The gallbladder was found to be enormously enlarged, measuring approximately 8 by 5 cm. The common bile duct was seen to be enormously dilated, measuring approximately 1.3 cm. in diameter. The common bile duct was palpated. No stone or induration could be felt. The head of the pancreas was then palpated and found to be of normal consistency. At the entrance of the common bile duct into the duodenum a papillary neoplasm was felt protruding into the duodenum. Although the gallbladder was very tense, upon pressure it was partially emptied into the duodenum. The tension of the gallbladder was then released by means of a trochar and cannula. The common duct was incised longitudinally. A lead probe was passed into the common duct and passed readily into the duodenum meeting only a slight obstruction at the papilla of Vater. The duodenum was mobilized by blunt and sharp dissection. Stone clamps were placed at the duodenal cap, and the duodenum was incised between the clamps. The pyloric stump was inverted by three layers of sutures. The duodenum was then freed and doubly clamped at the junction of the second and third portion of the duodenum and cut between clamps. The distal stump was inverted

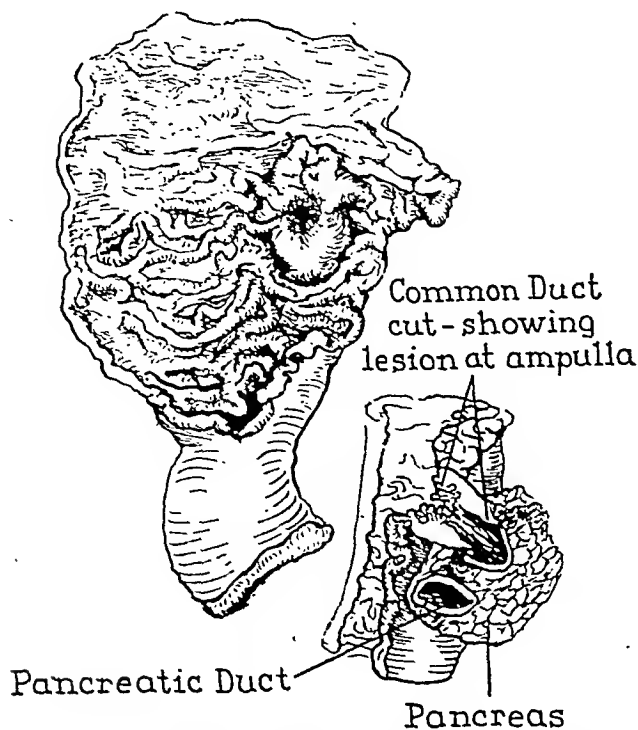


FIG. 2. Papillomatous tumor acting as a ball valve at the ampulla of Vater.

by three layers of sutures and the common bile duct was cut across approximately 3 cm. from the ampulla of Vater. A wedge-shaped portion of the pancreas was excised along with the duodenum and the distal portion of the common duct. The head of the pancreas was oversown with interrupted linen sutures, and a pad of fat was brought down to cover the inverted stump. The common duct was then anastomosed to the prepyloric end of the stomach with a water-tight suture line. The transverse mesocolon was incised, the proximal portion of the jejunum was brought through this opening and a side-to-side anastomosis was performed between the stomach and jejunum. The jejunum was then sutured to the edges of the incision in the mesocolon with interrupted sutures. (Fig. 3.) A Mikulicz drain was placed to the pancreatic bed. The peritoneum was closed with two rows of continuous No. 2 chromic catgut. The fascia was approximated, and the skin was closed with silk sutures.

The one-stage operation, whenever it can be done, is far superior to the two-stage operation. The complications arising from adhesions in a two-stage operation are avoided in a one-stage procedure.

Operative findings and procedure were choledochogastrostomy, excision of the first and second parts of the duodenum, excision of the

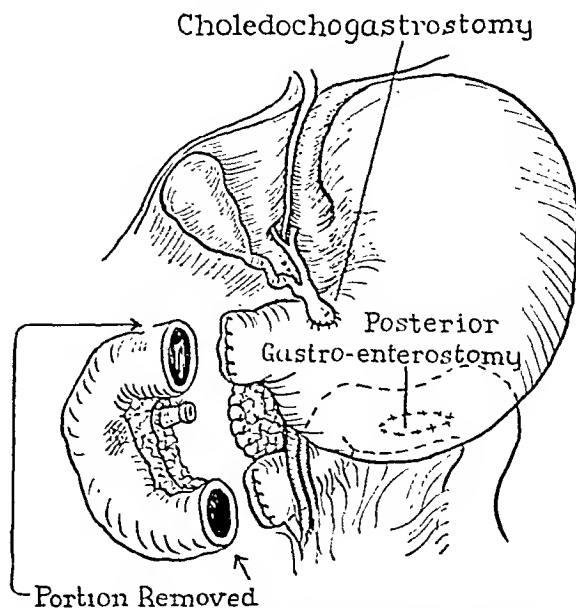


FIG. 3. A modified Whipple operation illustrating anastomosis of the common duct to the stomach.

head of the pancreas, gastrorrhaphy, jejuno-rhaphy and posterior gastrojejunostomy.

Clinical data and diagnosis reported carcinoma of the ampulla of Vater, marked dilatation of common bile duct and gallbladder and marked hepatomegaly. Macroscopically, the first specimen was a portion of duodenum including the papilla of Vater. It measured 9 cm. in length and 7 cm. in circumference. A small portion of pancreatic tissue was attached to the duodenum. Surrounding the ampulla of Vater there was a raised, ulcerated papilla measuring 2.8 by 1.2 cm. Its center was depressed and ulcerated. Two cm. of common bile duct were present. The latter measured 2 cm. in circumference. Its wall was thickened and its mucosa slightly roughened and mottled with yellow specks. Similarly, 2 cm. of pancreatic duct was present, measuring 1.4 cm. in circumference. Its wall was thickened and its mucosa congested. The neoplastic process at the papilla caused partial obstruction. On section the wall beneath the papilla was thickened, grey and infiltrated. The wall measured 1.2 cm. in thickness. The uninvolved duodenal mucosa appeared relatively normal. The attached pancreatic tissue measured 2 by 1.5 cm. and was slightly infiltrated with fatty tissue. There were several small, congested, greyish lymph nodes present on the serosal surface at the level of the papilla. The second specimen was a portion of common duct measuring 2 cm. in length by 1.2 cm. in diameter, with a



FIG. 4. Section of duodenal wall showing adenocarcinoma invading the muscle layer.

portion of pancreas attached, measuring 1.5 by 1 cm. The wall of the common duct was slightly thickened. Its mucosa appeared relatively normal. The attached pancreas resembled the pancreatic tissue described above.

Microscopically, a primary, ulcerating adenocarcinoma had penetrated as deeply as the outer muscle layer. (Fig. 4.) It was also seen in the serosal fat in the neighborhood of lymphoid tissue. The small lymph nodes sectioned showed no metastatic involvement. The pancreatic tissue showed extensive fibrosis.

Pathological Diagnosis: The duodenum reveals a primary ulcerative carcinoma of the ampulla of Vater with extension into the regional fat and lymphoid tissue. The pancreas showed a chronic fibrosing pancreatitis. The common bile duct was normal.

Comment. Jaundice was present in this patient for one year. One should be reminded of the fact that jaundice which has persisted for twelve months should have had some surgical remedial measure performed long before this case was assigned to the surgeon. The history states in full the characteristics in this case, but the main physical sign was that of Courvoisier's sign which is usually confirmatory of some malign-



FIG. 5. X-ray taken one year after the operation, illustrating the evacuation of barium through the gastro-enterostomy.

nant condition at the ampulla of Vater or the head of the pancreas. As a result of the character of the growth which was a papillary carcinoma at the ampulla of Vater, the jaundice would occasionally disappear. It acted, in other words, like a ball valve stone. A successful one-stage, modified Whipple operation was performed. The essential step in this modification was the performance of a choledochogastrostomy. The convalescence from this operation was excellent. As a matter of fact, ten days after operation the patient could have left the hospital. The presence of bile in the stomach as a result of this type of anastomosis caused little or no disturbance. She did not vomit bile or any other stomach contents following the operation. There was practically no drainage from the wound following the introduction of a Mikulicz drain for leakage that might have occurred. A small amount of serous fluid exuded.

Follow-up of Patient. In August, 1945, there was no jaundice. The patient had not

gained any weight but she felt perfectly well.

In November, 1945, her complexion was clear but there was no gain in weight. She stated that there were lumps along the line of the abdominal incision. These nodules were subjected to radiation. Following operation for gastrointestinal carcinoma nodules are frequently seen occurring around the healed abdominal wound. These secondary tumors are usually radiosensitive. In only one case was it necessary to remove the metastases after the use of x-ray.

In January, 1946, the patient was readmitted to Mt. Sinai Hospital. The skin was perfectly normal in color; there was no jaundice of the sclera; the metastatic growth in the wound was much smaller than on the previous examination due to the x-ray treatment. There was some evidence of weight loss, but the patient was cheerful and happy. The bowel movements were not acholic.

On January 22, 1946, the x-ray examination revealed the following: the esophagus and stomach were normal in size, shape and position. The stomach was fixed and tender on palpation. Gastric peristalsis was sluggish but evacuation was rapid through the gastro-enterostomy. There were no evidences of gastric or pyloric lesions.

The duodenum showed filling of the first portion only and this appeared slightly deformed. There was a fine fistulous tract just above the pylorus in the region of the pancreas filled with barium.

On January 7, 1946, the nodule in the abdominal wound was excised. Microscopic examination revealed a secondary adenocarcinoma of the rectus muscle.

The patient was discharged January 17, 1946, and was in the usual optimistic frame of mind. Slight jaundice was present and a noticeable loss of weight was observed.

Comment. The patient lived in comparative comfort for one year following the operation. She was free of pain and jaundice up to her recent admission a few weeks ago. She had had no digestive disturbance. There was no steatorrhea or any change in the bowel movements. On her last admission (January, 1946), a physical examination of the abdomen revealed definite hardness and some rigidity in the epigastric region. This was due no doubt to the metastatic growth in the abdominal wall and also to an enlarged liver. She did not complain of pain or other discomfort in this area. Her skin on admission was clear, but after the removal of the nodule in the abdominal wall for microscopical examination she became jaundiced again. After a few days this jaundice faded considerably. It is interesting to note the changes in laboratory examinations of a year ago as compared to those taken upon her last admission.

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CONGENITAL HERNIA IN A MALE CONTAINING A RUDIMENTARY UTERUS

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MUCH has been written about hermaphroditism as to embryologic, anatomic and hormonal aspects, but these cases are of little clinical importance other than as medical curiosities. It is the purpose of this paper to discuss the clinical aspect of tubular pseudohermaphroditism in males and its relation to congenital hernia and cryptorchidism. A tubular pseudohermaphrodite is a person having the glands of one sex and at the same time bearing the tabular accessory structures of both sexes. A case is reported, but of greater significance, the attention of physicians and especially of surgeons is called to the possibilities of such cases. The syndrome of "Hernia Uteri Inguinalis In Men," as first used by Nilson, is characterized by congenital hernia containing a uterus and associated very often with contralateral cryptorchidism.

It is well known that early in fetal life every person is potentially bisexual. The gonad, arising from the genital ridge, potentially contains the primordial structures of both ovary and testis. In the normal male the testicular tissue dominates, under chromosomal and hormonal influence, reducing the potential ovarian tissue to vestiges. Likewise, two sets of tubular structures appear, the Wolffian and Müllerian ducts. In the male, the vas deferens, the seminal vesicle, and the epididymus are formed from the Wolffian duct. The Müllerian duct normally atrophies leaving only vestigial remains, namely, the canals of Rathke, the non-pedunculated hydatid, and the prostatic utricle. The non-pedunculated hydatid, when present, is found on the testicle and represents the cephalic end of the Müllerian duct; the prostatic utricle

near the center of the posterior surface of the prostate gland represents the caudal end.

It is probable that completeness in reciprocal degeneration and growth is rarely produced and that varying degrees of low grade intersexuality occur normally, as evidenced by rests of primary gonadal tissue in ovaries and vestiges of the two paired ducts in both sexes.

Between the extremes of a few cases of true hermaphroditism as evidenced by microscopic finding of an ovotestis, and the overwhelming number of normal males with only vestiges such as the canals of Rathke, the non-pedunculated hydatid, and the prostatic utricle as rudiments, are a number of cases of tubular pseudohermaphroditism with which we are particularly concerned.

CASE REPORT

R. M., a thirty-eight-year old white male, was admitted to the Sewickley Valley Hospital on October 1, 1944. His complaint was of a right inguinal hernia which had developed gradually at the age of sixteen but since that time had not increased in size. A support has been worn for the past twenty years with great success. The only symptom was slight pain during the development of the hernia, but during the past twenty years he has been entirely symptom free except for an occasional twinge of pain felt in the inguinal region when the mass slips into the scrotal sac. He presented himself for surgery only at the insistence of his employers.

His past history revealed scarlet fever at twenty-one and pneumonia at the age of eighteen. There was no history of venereal disease. He was married at twenty-eight, leading a normal and happy marital life, except for

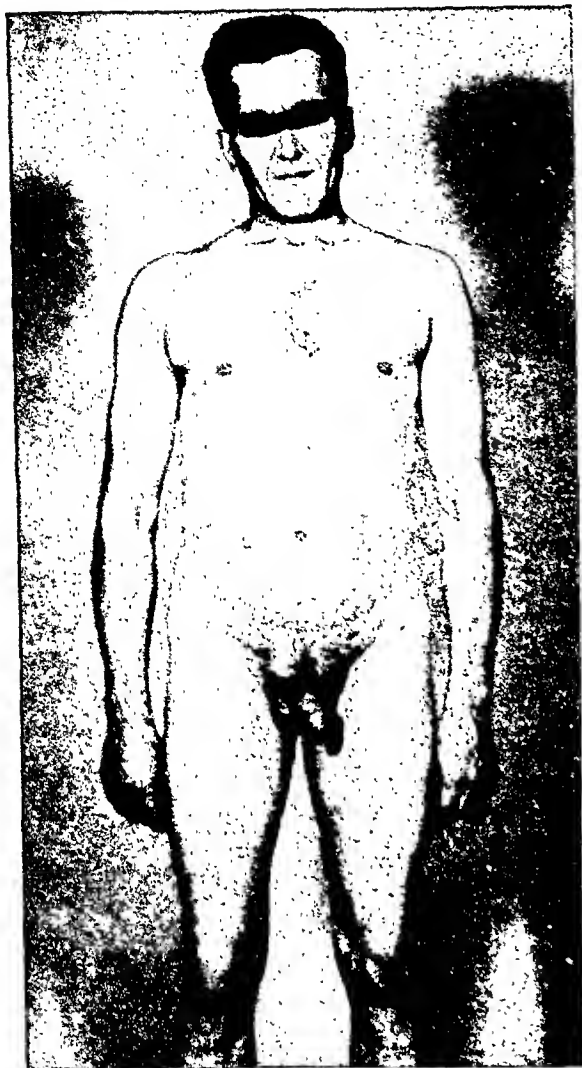


FIG. 1. Photograph illustrating normal genitalia, and normal male secondary sex characteristics.

the unrealized wish for children. In 1940, he sought medical help in an effort to remedy this. Unfortunately, complete sterility investigation was not undertaken. However, examination of his wife was entirely negative. A specimen of sperm removed from the seminal pool showed poor motility and an increased number of atypical forms. The patient had noticed a diminishing libido in the past few years.

Physical examination revealed a well developed, robust white male in good general condition weighing 182 pounds and being 5 feet 10 inches tall. His beard was full but soft and he was pink cheeked. His blood pressure was 190 systolic with an average diastolic reading of 90 mm. of mercury. The A:V ratio of retinal vessels was 2:5. Moderate tortuosity and moderate blurring of the A:V crossings was present. Detailed examination was otherwise negative except for the presence of a relaxed right external inguinal ring which easily ad-

mitted two fingers. A cough impulse was present on this side. Both testes were of normal size and consistency. The penis and prostate gland were unaltered.

Usual laboratory tests were all within normal limits. Both Kolmer and Kahn tests were negative.

At operation a mass about 2 cm. in diameter and 6 cm. in length, was found in the right inguinal canal. A sac was not demonstrable. The surgeon was puzzled but believed that the mass was a group of varicose veins which had undergone inflammatory changes brought about by the truss which the patient had worn for a great many years. The vas deferens was so incorporated in the mass that a portion of it was removed. On the left side a small indirect hernia was found, the sac was ligated, and the repair completed.

Macroscopically, the specimen was a tough, shaggy, irregular mass of formalin fixed tissue which measured 63 by 25 by 25 mm. Multiple sections revealed the mass to be composed of a hollow tube with a smooth mucosal-like lining and a smooth muscle wall. Adherent to one side were many dilated tortuous veins and a portion of the vas deferens.

Microscopic examination of sections through the mass revealed it to be composed of a smooth muscle wall with many bundles running in interlacing courses, resembling the wall of a uterus. The lumen was lined by columnar epithelium and beneath this lining there were many regular gland-like structures resembling those seen in the endometrium. There was no true endometrial stroma but some small cells near the surface resembled stromal cells. The pathologist's diagnosis was rudimentary uterus found in an inguinal canal. Nothing resembling ovarian tissue was found.

Eight months postoperatively, the repairs were intact and the patient was in good health. However, shortly after the operation he lost 12 pounds which he had been unable to regain. He also volunteered information concerning his beard, which he believed is definitely more coarse and more difficult to shave. For four months libido was further decreased but since then has increased. He is now more hopeful than ever before of having a child. A sperm count nine months postoperatively revealed a marked reduction not only in motile spermatozoa but an overall total reduction. Atypical forms constitute 35 per cent of the sperm present.

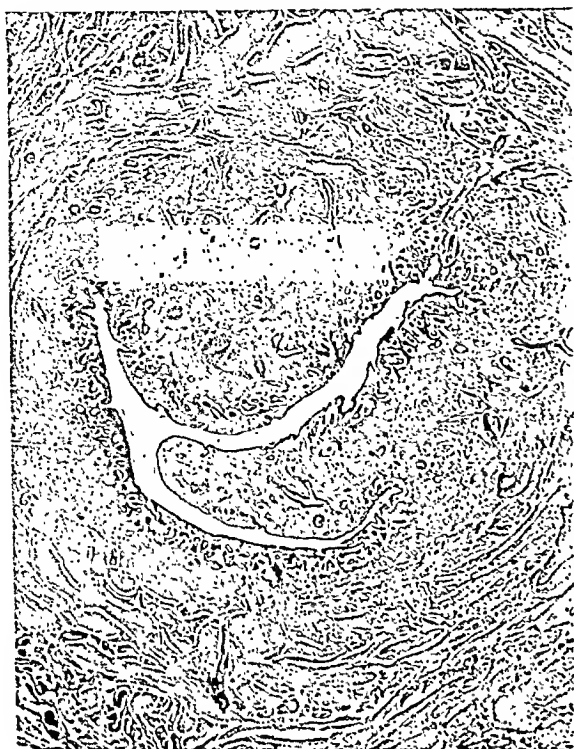


FIG. 2. Microphotograph of rudimentary uterus removed from right inguinal canal of a male. $\times 10$.



FIG. 3. High power microphotograph of rudimentary uterus removed from right inguinal canal of a male. $\times 120$.

Briefly summarizing the thirty-six existing reported cases reveals certain common and important findings: (1) Sixty per cent of the hernias were scrotal. (2) In 86 per cent of the cases there was cryptorchidism. In twenty-one of the cases (70 per cent) the cryptorchidism was contralateral; in four cases (13 per cent) the cryptorchidism was bilateral; in one case the cryptorchidism was on the side of the hernia. (3) The size of the uterus was variable but most often normal. In three cases the organs consisted of undifferentiated Müllerian duct; in three cases a well differentiated bicornuate uterus was present; in five cases the uterus was rudimentary; in four cases the uterus was oversized; in eight cases no statement was made. (4) In no case was there any ovarian tissue discovered. (5) In only a few cases were the marriages productive of offspring.

The maldevelopment or more accurately a lack of reciprocal degeneration may be due to hormonal influence. Just where this hormonal influence arises is difficult to say

for complete histological studies and hormonal assays were not done. It is not impossible that rests of ovarian tissue may be present and that these secrete sufficient hormones to prevent reciprocal degeneration. By puberty, when the male characteristics make themselves most prominent, these rests may have degenerated. The cause of the accompanying hernia and cryptorchidism is almost entirely mechanical. When the gubernaculum draws down the testis to which the persistent Müllerian duct is attached by its cephalic end, the latter accompanies it and further enlarges the internal inguinal ring. The increased mass seems to prevent the obliteration of the processus vaginalis. Whether or not this increased mass or the presence of inelastic and muscular uterus is the cause, it is a fact that migration of the uterus with one testis is often accompanied by contralateral cryptorchidism unless the uterus is infantile or rudimentary.

Thus though there may be many variations, the majority of cases follow so

similar a pattern as to constitute a syndrome. These cases are seen in apparently normal males at any age but usually early in life and are characterized by an indirect inguinal hernia, often scrotal, the contents of which are firm and unyielding. There is almost always cryptorchidism, most often contralateral. While the secondary sex characteristics are normal, the individuals are not strongly masculine, the beard being soft and libido decreased. The marriages of these men are usually barren. The patient presents himself to the physician, if at all, for treatment of the hernia and more rarely for the cryptorchidism. The size of the hernial mass varies with the state of development of the uterus but often is in a great part due to other organs present in the sac such as intestine or omentum.

Diagnosis was not made preoperatively in any of the cases; often not even at the time of operation, usually because of unawareness of such states. The diagnosis can be made preoperatively; at least it should be strongly suspected in a patient complaining of congenital hernia and contralateral cryptorchidism. Palpation of the uterus in the canal is very important but not entirely diagnostic because its firmness may be simulated by a mass of omentum, by a lipoma or a malignancy of the sac. It is important that the diagnosis be made at the time of operation for the treatment depends upon it. The ease with which these cases can be recognized will of course depend on the state of development of the uterus and adnexa.

The treatment is conservative. In most cases the uterus should be removed to affect a good and lasting repair. Care must be taken in the "hysterectomy" because the vas deferens lies in close apposition to it and might easily be damaged or destroyed. If the uterus is attached deep in the pelvis, the remaining stump must be thoroughly closed since it is continuous with the penile urethra.

In cases with cryptorchidism, the testicle should be placed in the scrotum. If this is

impossible it should be removed, because of the danger of malignant degeneration if the testis is allowed to remain in the abdominal cavity.

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TRAUMATIC RUPTURE OF A HYDROCELE SAC

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TRAUMATIC rupture of a hydrocele sac is a rather rare happening and it is to bring this occurrence to the eyes of the medical profession that the authors believe this case should be reported. Traumatic rupture of the hydrocele sac has been reported before; the last comprehensive report was that of Collins in 1930, who reported an analysis of sixty-one such cases.

The etiology of this happening is direct trauma to the hydrocele sac, which results in rupture of the tunica vaginalis.

The symptoms are acute and constant severe pain, sometimes with profound shock and swelling of the scrotum. The edema and discoloration may be sharply limited to the scrotum or may extend to the adjacent abdominal wall and the suprapubic region and the penis itself. If this condition is borne in mind, the diagnosis is usually not difficult to make.

The only adequate form of therapy for this condition is evacuation of the fluid and the accumulated hematoma, with the usual repair of the hydrocele sac.

CASE REPORT

T. M., (The Long Island College Hospital, No. 227485), a thirty-one-year old longshoreman, presented himself in the Emergency Room with a complaint of severe pain and marked swelling in the scrotum and penis.

He stated that he had had a tumefaction in the left scrotum for the past year and a half, which had neither grown larger nor smaller during this time, and was about the size of an orange. This had given him no pain until approximately forty-five minutes before ad-

mission to the Hospital when, while stepping on to a chair which slipped from under him and struck him in the scrotum, he experienced severe pain in the scrotum but no loss of consciousness. The patient was brought to the Hospital in an ambulance.

Physical examination on admission revealed a young, healthy adult male in acute distress and complaining of pain in the scrotum. The only abnormal findings were limited to the scrotum and adjacent areas. The left scrotum was ecchymotic as was the penis and the left inguinal region. The scrotal mass was painful to touch and very soft and fluctuant throughout and was soggy. The penis was markedly edematous and ecchymotic, being approximately three times the normal size. The corpora could be felt within this edematous area and the glans could be exposed by retraction of the foreskin and was normal in appearance. The patient voided spontaneously and the urine was negative, including microscopic examination. The patient was put to bed and treated with hot packs to the affected parts, and the next day the swelling in the penis had markedly reduced but the ecchymosis, swelling and tenderness in the scrotum were still present.

The patient was taken to the operating room where, with a two and one-half inch incision, the left testicle and investments were exposed. Much blood clot was evacuated and the tunica vaginalis was found to have a rent in the anterior wall which was about one and one-half inches in length. After the hematoma had been evacuated, the tunica vaginalis was stripped from its surrounding tissues and the redundant portion of the tunica vaginalis was trimmed off to approximately one-half inch of its visceral insertion. The cut edges were then sewn together behind the testicle. A Penrose drain was placed in the depths of the wound behind the

testicle which was replaced into the wound, and the wound was closed in layers.

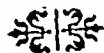
The patient's postoperative course was entirely uneventful. He drained serosanguineous fluid for about seventy-two hours. The Penrose drain was removed in four days. The wound healed primum.

The patient was discharged on his ninth postoperative day and was instructed to wear

a scrotal suspensory. He was followed in the Out-Patient Department for one and one-half months, at which time the wound was entirely and completely healed and the serotum had returned to normal size.

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CASTRATION is indicated for malignant tumors, selected cases of torsion, advanced tuberculosis, certain severe injuries, undescended testis when too high in the abdomen to place in the serotum, and as an elective procedure in certain very large hernias to permit some secure plastic repair.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

Bookshelf Browsing

GASTROSTOMY

ITS INCEPTION AND EVOLUTION

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DOWN through the years involved in the development of medical science, there has run a line of continuity sometimes not too easily discerned, but rather readily visible to one delving here and there into the medical literature of the past.

Some years ago considerable time and search was spent and an article published outlining only the highlights in the development of gastro-enterology as a subspecialty or branch of medicine. In gathering the material together for that article one could not help noting the orderly array or marshalling of facts leading up to new discoveries. Always at first, there were theories, finally proof. It seemed that as soon as a way or means of doing something or explaining something in procedure was discovered, and then finally proven, it was not the end by any means. A door closed as in a room but opened immediately into another, to other theories or ways possibly closely related, sometimes not, which then posed a new challenge and had to be worked out and proven, too, in order to clinch proof beyond the point of contestability. Thus has the search in science been endless and forecasts that it always will be.

In the article as finally published, the whole nature of a science was described as the foundation of a structure on which must be built in time the final edifice. Each new fact gathered and added to the structure could be imagined in the form of a brick—the discoverer, an artisan working temporarily on the project but adding his brick or bricks to the structure, many

after and before him, contributing their quota until a respectably sized structure was realized.

Peculiar unto science is the fact that the structure is never near completion, probably never will be completed as there will always be phenomena that man will want to know about and understand so that the structure goes on attaining size.

It has always been a peculiarity of science, particularly of medical science, to withhold acknowledgment of a deed well done, usually a valuable discovery contributed, until long after the original worker has passed on, and has therefore been deprived of any satisfaction and glory he might have enjoyed, had his work been acknowledged during his lifetime. The pages of medical history are full of experiences of men who have uttered truth, which has been accepted by the medical body as a whole only after much controversy, criticism and bitterness.

Another curious custom of medical science is that in many instances, discoveries have lain buried for a long period of time, the original discoverer probably having given up the battle for acceptance of his idea because of sheer mental or physical exhaustion. When some enterprising opportunist comes across such a piece of work and this is usually by accident, such an opportunist adds or changes a word here or there, then announces to the world his own particular little brain child, never giving credit anywhere to a deserving worker in the field, who, having passed on, is not able to present his priority claims

and worse still no one sufficiently interested to do it for him.

All of which leads up to a bit of accidental reading, wherein one could not help but be astonished at the application of this very method of conduct to such a comparatively minor procedure as a gastrostomy; and inasmuch as persons involved in such conduct are contemporarily active, an effort is made herein to review the history of the development of the technics giving credit where credit is due and establishing priority by the chronological recording of each man's work as established by published printed matter, available at any medical library for corroboration or verification.

Mindful of the admonition of Moynihan that before writing on any medical subject it would be well to see what Osler may have said on the subject, the bibliography of Osler's writings has been diligently searched but nothing pertinent encountered probably because Osler was primarily a pathologist and clinician and not very much interested in surgical procedures, although we know that he attended Billroth's Clinic diligently while he was in Vienna and even went so far as to do some cadaver surgery with Billroth's assistant and advised many of his medical friends visiting in Europe to do likewise.

It is again a peculiarity of medical science that often a finished discovery is not the work of one man, may even be that of several men working at the same time, unknown to each other, but putting together several pieces, then the addition of the master piece to produce the whole, the original first piece having been discovered by some obscure worker many long years before. Such is the usual story in a finished opus. Witness the story of the development of insulin. One has to go back to De Graaf, Von Haller, Claude Bernard, Pavlov, to name only a few great names contributing their all to knowledge of the pancreas.

Each contributed an important single piece of knowledge of pancreatic physiology. Banting and Best made use of this

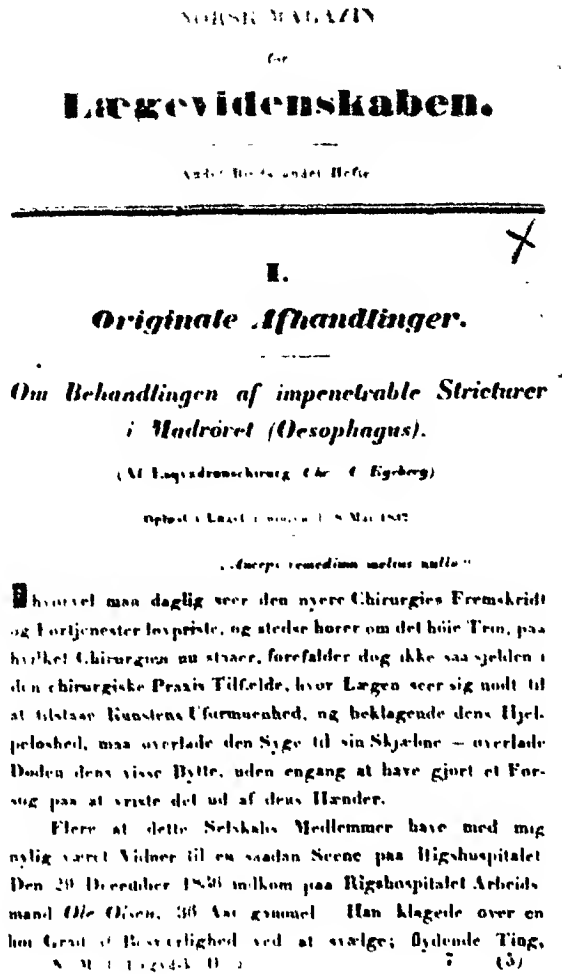


FIG. 1. A, facsimile of title page of Egeberg's lecture in 1837.

knowledge, went forward, found the master piece which was missing, and arrived at a goal, insulin. But both men, having accomplished successfully what they set out to do, gave adequate credit to the enormous value of the discoveries of their predecessors in the field. The story of penicillin practically parallels this.

The first operation ever done on a human stomach was gastrotomy, which came about as a necessity of the times. Mental deficiency being apparently in much greater prevalence in early days (meaning the fifteenth, sixteenth, and seventeenth centuries) than at any time since, and the swallowing of bizarre objects, accidentally, or as an occupational hazard or otherwise, particularly by members of travelling circuses and shows, being of great frequency, necessity forced the daring needed

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FIG. 1. B, facsimile pages containing the gist of Egeberg's remarks.

to open the stomach to remove the various
and sundry objects within.

One glance at the paintings of the
Middle European masters of the sixteenth
and seventeenth centuries illustrates that
whether or not they knew what they were
painting, a large number of hydrocephalics,
microcephalics, cretins, and mongolian
idiots can be made out in any scene wherein
groups of people are painted. This is par-
ticularly true in the paintings of the Dutch
and German masters, specifically, Holbein
and Breughel. But what as to gastrostomy?
In order to discuss any subject intelligently
it is necessary to have a clear cut definition
and picture of it in mind. Gastrostomy
consists in the creation of an artificial
opening into the stomach from the outside
for the purpose of introducing food or medi-
cations therein.

Historical accuracy will have to give
credit to a Norwegian Army surgeon,

named Egeberg¹ for first proposing such
an operation in a lecture and anatomical
demonstration before Army Officers in
Copenhagen in the year 1837. The record
is that he was discussing a case of carcin-
oma of the oesophagus. Details of his pro-
posed approach and technic are not
available.

It is well to recall here that the eighteen-
thirties were the days of Alexis St. Martin
and the United States Army Surgeon
Beaumont. This case had received world
wide publicity and Doctor Beaumont's
own account of his experiences with "fistu-
lous Alex" had been published in 1830 in
Plattsburg, New York, was almost imme-
diately received and commented on in
London, and the spread of both Beau-
mont's fame and that of his case to other
centers of medicine in Europe was almost
instantaneous.

It could well be that Egeberg had either

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Ministre de la Guerre, que des les premières années de l'occupation de l'Alsace par l'armée française, il fut question d'y introduire la cochenille. On mit à l'épreuve, selon la personne qui avait été chargée de diriger cette culture, plusieurs ars arpentés de terre; après deux ou trois ans d'essais fort dispendieux et complètement sans succès, on jugea que le climat n'était pas favorable à ce que l'insecte colorant ne pouvait réussir. La personne chargée de ces essais, ignorant que le précieux cochenillier se trouve en particulier qu'il est principalement cultivé et multiplié, l'avait placé sur les bords de la Moselle, si communs dans le pays, et il y mourut. Heureusement qu'il se trouvait en même temps sur les lieux deux botanistes aussi habiles que nos autres les frères Monod, qui, s'étant procuré à Malaga, où existait depuis un certain temps de petites nupharées, quelques plants du *Coccus coccinelliferus*, en avaient répandu dans le pays, de sorte que lorsque M. Huby arriva en Alsace, il put juger du parti qu'on pouvait tirer, d'une pauvre source de richesse; et comme dans tout ce qu'il a entrepris jusqu'à ce jour pour le bien de la colonisation, ses efforts ont été couronnés par les plus heureux succès, je n'ai donc rien à dire sur ce que j'en ai vu, que grâce à ses intelligentes entreprises, la culture en grand de la cochenille est entièrement acquise à la France dans ses possessions transalpinnes.

M. DeMeunier, correspondant de l'Académie, annonce l'envoi de divers ouvrages des Mémoires de l'Académie impériale de Saint-Petersbourg, ainsi que des Mémoires et du Bulletin de la Société impériale des naturalistes de Moscou; ces volumes, dont plusieurs sont aujourd'hui très-rares, et que la bibliothèque avait cherché vainement à se procurer, sont déjà arrivés et complètent trois collections précieuses.

M. Denodott, dans la lettre qui accompagne cet envoi, exprime le regret de ne pouvoir compléter la Description du Muséum Denodott, faite par l'auteur et publiée à Moscou en 1809; la livre, qui se rattache à la publication des Mémoires de la Société des naturalistes de Moscou, est devenue très-rare.

NOTES. — De la Gastrostomie fistuleuse, par M. C. Sédillot, correspondant de l'Institut.

Je donne le nom de *gastrostomie fistuleuse* à une opération consistant à établir aux parois de l'estomac une ouverture permanente, dans le but de ramener à l'alimentation une voie artificielle, chez les malades qui ont cessé tout à fait de l'usage de la nourriture.

mons que la privation d'un acte naturel quelconque, *marquait* la perfection du résultat physiologique; mais quel en serait le résultat? On peut assurer que les effets en seraient très-lents et très-peu marqués. Plusieurs mois un malade en un servant de la sonde œsophagienne, succomba à des accidents tout à fait indépendants d'une altération de nutrition.

La mastication est une opération mécanique facile à reproduire artificiellement. L'insalivation resterait donc seule en cause; mais, comme la salive ne serait pas sécrétée avec abondance, cette mastication servirait, jusqu'à un certain point, à suppléer.

1. Mais n'y aurait-il aucun moyen de rendre la masse alimentaire identique à sa composition normale? Ce problème serait d'une facile solution. Bien n'empêcherait les malades de préparer le *bol alimentaire*; et même, s'ils étaient carochymies, atteints de stomatite, privés de dents, on pourrait, en leur faisant avaler cette préparation à des personnes jeunes et saines, leur faire rendre la digestion en seraient rendues meilleures.

2. Je ne puis, par des considérations empruntées à la pathologie et à la physiologie humaines, que la gastrostomie fistuleuse était une opération parfaitement fondée en théorie et en fait. Je pourrais m'abstenir d'invoquer comme les expériences entreprises sur les animaux; j'en dirai seulement quelques mots.

L'opération réussit très-bien sur les chiens, et M. Blondlot en possède un qui porte, depuis plus de deux années, une fistule stomacale. Il pratique trois fois cette opération; et trois fois avec un succès complet. Dans ce moment, par, dans mon amphithéâtre, deux de ces animaux que je nourris entièrement par leur fistule.

1. Tel est l'aperçu très-sommaire des considérations sur lesquelles je fonde l'indication et les probabilités de succès de l'opération que je propose.

2. J'aborderai maintenant l'étude approfondie des sujets que j'ai à peine ébauchés, et je traiterai successivement.

1. Des retencements de l'œsophage, dans lesquels la gastrostomie fistuleuse est indiquée;

2. Des fistules gastriques, accidentelles et permanentes, compatibles avec la vie;

3. De l'état de la nutrition chez les malades nourris au moyen d'une sonde œsophagienne.

4. Des effets de l'alimentation entretenue sur des chiens par une fistule stomacale.

FIG. 2. A and B, facsimile pages of Sédillot of Strasbourg; observations and reports upon gastrostomy.

heard of or read of Alexis and of Beaumont's observations and how he had made them; but it is on record that he advanced as argument for the operation the fact that he knew personally of cases of gastrostomy that had survived, and that he himself could see no reason why if you could operate successfully to take things out of the stomach you could not reverse the procedure and operate to put things in. There exists no record, however, that Egeberg may have tried to do this operation personally, and also no record that he advocated any particular technic for doing it.

Then again it is reasonable to speculate that Egeberg may have been conversant with European reports of other cases similar to Beaumont's. That fiery petrel of New England medicine, Benjamin Waterhouse, had returned from Europe

with an account of a case he had seen on the wards of the Allgemeine Krankenhaus in Vienna, which in all respects was similar to Alexis'. Waterhouse, on reporting this case, was immediately challenged as to its authenticity (he would have been challenged on anything he might have said anyway) and had to write to Vienna to obtain proof that he was telling the truth; which he so did. By some trick of fate the publicity flare for Beaumont's case took hold and the Vienna case sank into obscurity. Had it been otherwise, the Vienna case would have antedated Beaumont's by about twenty-five years.

Egeberg, may have had knowledge of this Vienna case, as accounts of it had appeared in Medical Journals throughout Europe, or he may have had knowledge of similar cases elsewhere.

Une nouvelle opération de gastrostomie (procédé valvulaire).

Par le Dr FONTAN, de Toulon,
Professeur à l'école de médecine navale.

L'opération qui fait l'objet de cette communication avait pour but l'établissement d'une fistule stomacale pour assurer l'alimentation chez un homme atteint d'un rétrécissement infranchissable de l'œsophage : c'est-à-dire qu'elle répondait à une indication d'urgence absolue. Elle ne se distingue des gastrostomies courantes que par le soin avec lequel la bouche stomacale a été située dans le dédoublement d'une valvule dont la formation fut réalisée extemporanément au début de l'opération. Ce procédé a pour but d'éviter la corrosion des lèvres de la plaie qui résulte si souvent des ouvertures directes; il s'éloigne aussi de tous les trajets obliques, sous cutanés, comme des opérations en deux séances et des autres manœuvres compliquées par lesquelles on a cherché à éviter l'écoulement du suc gastrique et ses inconvénients.

Avant de vous en donner la description technique, un mot sur le malade qui nécessita cette intervention.

Observation. — Chatel, premier maître de la marine, qu'il sert déjà depuis vingt-deux ans, a avalé par mégarde une gorgée, dit-il, d'une solution concentrée de potasse caustique. D'où après plusieurs mois de souffrances, un rétrécissement cicatriciel de l'œsophage. En mai 1894, on note que l'atrésie siégeant à 24 centimètres des arcades dentaires ne laisse pas passer une sonde du n° 18 de la filière de Charrière. Après des améliorations douteuses et bien des vicissitudes par le traitement dilatateur, le malade tantôt gagnant, tantôt perdant, en est arrivé, en mars 1895, à ne pouvoir se nourrir qu'avec la plus grande difficulté. Ne réussissant à avaler que quelques gouttes de lait ou de bouillon peptonisé, il s'achemine à la consommation, à l'inanition complète. Le faciès s'altère, les yeux se cernent, les veines se dessinent bleuâtres sous la peau transparente; enfin l'hypothermie est presque constante (36°.1), entrecoupée de poussées fébriles; la constipation opiniâtre, la faiblesse

FIG. 3. Facsimile of Fontan's contribution.

1837, but we can find no record of his having performed the operation, neither did he suggest any technic or approach to accomplish the procedure.

Sédillot, of Strasbourg, actually performed the operation, first on dogs and then on human beings, and actually described an operative technic which he deemed best and there is printed evidence that he actually formulated and put into execution a surgical procedure and plan for doing a gastrostomy. To Sédillot, of Strasbourg, France, should credit for origination be given, based upon complete absence of any plausible claim for priority for anyone else and on the basis of his original article, entitled "De la Gastrostomie Fistuleuse" published in France in 1846, and a second article followed seven years later entitled "Observation de Gastrostomie," in which he related his experience when he performed the operation on three humans. There exists, therefore, actual printed ma-

terial as described above, ample evidence in any court of opinion, as to who should have the credit as the originator of the operation.

Many great names in medicine had thought about an approach to the stomach, thinking along the same lines that Egeberg did in Christiania in 1837, that if you could cut into the stomach to take out something, why couldn't you cut in to put something in. (Fig. 2A, B, C, D and E.)

If one hies back to the earliest days in medical history, it is of interest that Hippocrates, Galen, Guy de Chauliac, Hugo of Lucca, Lan Franco, and other great personalities speak of operations on the stomach to repair stab wounds and such, but no description of any procedure which might be construed to be a gastrostomy.

Man lived rather precariously in those days, usually by the sword, so that stab wounds of the abdomen were relatively

common. Wars, small and petty though we might label them compared to our twentieth century supercolossal shows, were fought in the main by men on foot with swords or cutting armaments and as a man's abdomen was a very vulnerable piece of anatomy, if it could be reached with a weapon thrust, such procedure insured putting an enemy entirely out of the running immediately and it did not much matter whether he died instantly or just a bit later. That necessity—the repair of cutting penetrating wounds of the abdomen, and not infrequently of the stomach—forced the issue and brought about the first operative procedure on the stomach—gastrorrhaphy—but as it was merely a repair job, priority for first operation is usually given to gastrostomy.

This operative procedure on the stomach cannot truly be said to have been the child of necessity, as certain elective factors were involved. Two basic environmental factors certainly influenced its origination.

The usual form of entertainment available throughout middle Europe in the fifteenth, sixteenth, and seventeenth centuries was the travelling caravan or the circus of the time. Usually these travelling caravans were overbalanced with jugglers, sword swallows, and similar types. Accidents happened sometimes, and somebody found himself with something swallowed or dropped into the stomach which was not strictly in the routine. What more natural than a fearful rush to some surgeon with the demand that it should be removed, as who could tell what the end result might be. To remove anything from the stomach required cutting into it—*ipso facto*—gastrostomy. Thus was that operation born.

The other influencing agent is admittedly to some extent conjecture. Not wishing in any way to assume the cloak of an iconoclast, yet a rather diligent search of the medical lore attendant upon the Crusades made such an unfavorable impression that it is a bit excusable if one's reflexes become conditioned to looking upon many happen-

ings of those early days with not only a quizzical, skeptical eye, but also one that is cynically jaundiced.

In the days of ancient Egypt those people who were "in the money" paid fabulous sums for bezoars. Stones found in the bladders or stomachs of animals brought fabulous prices, and stones from certain animals were presumed to be possessed of great power in warding off fevers or pestilence. Others possessed curative properties in epilepsy, scrofula and such. But the most fabulous prices of all were paid for a stone from a human stomach, and those who were able to negotiate to obtain one usually had it set in fine gold and surrounded with precious stones, the finished piece hanging on a chain around the owner's neck, never to be taken off, so that it could always be there to ward off evils, fevers and what not.

Now such a situation could not do otherwise than bring on a bit of skullduggery. Those who cast envious eyes on such a possession were not above indulging in a bit of sword play trying to get possession of it—contributing thereby indirectly to the experience rate of gastrorrhaphy; and the lure of gold and the lust for it has not changed in the human species, so many a clandestine surreptitious gastrostomy might have been done, thereby emboldening certain surgeons to take the next necessary step in answer to the question, "why can't I do this legitimately?" Such a situation could lead to much racketeering as usually happens when there is plenty of money around to pay for it.

The next step in the orderly evolution of the science brings us back to about the year 1856, and those who came after Sédillot. He had published the two articles mentioned relative to his procedure—one in 1846, in the *Gazette de Strasbourg*, and one in 1853, in the *Gazette d'Hopitaux*. Because of the two handicaps of Sédillot's procedure, peritonitis and skin digestion, it was only natural that someone should try to improve on his technic.

We then find a long list of names asso-

associated with this attempt at improvement of the operation, a seemingly all too long list: Von Hacker, Czerny, Witzel, Stamm, Kader, Kocher, Dépage, Janeway, Senn, Babanajeff, Jianu and Hahn. All believed according to their published articles that whatever particular wrinkle they personally contributed to the original operation had made it work perfectly, at least in their estimation; yet a fair but critical analysis cannot fail to give one an impression that some of these men, simply by reversing the suture technic or by placing an eccentric row of sutures instead of the orthodox and accepted way, hoped to reap unto themselves much unearned credit. In other words, one wonders if they were not more interested in "crashing the headlines." In the list of names just mentioned, one name has been purposely withheld, that of a Frenchman named Fontan.

Sédillot,² in publishing his experience with gastrostomy on animals and humans, gave to the operation the name of "gastrostomie fistuleuse"; and it was known as such by subsequent French surgeons who contributed additional steps in the technic, endeavoring always to perfect the operation and rid it of some of its deficiencies.

Fontan,⁴ a brilliant Strasbourg surgeon, realizing that the operation had very definite indications and uses, made first a series of animal experiments, all directed toward making the fistulous tract leak-proof and thereby avoiding the excoriation of the skin.

He availed himself of the principles worked out by two contemporary French surgeons, namely, Pelière of Toulouse and Pénieres,⁵ in their respective laboratories, but it was he personally who really perfected the procedure to such an extent at least that in French surgical literature the operation and technic were constantly referred to as the Fontan operation and the particular method of manufacturing a valve device from the stomach walls the "Fontan valve."

So along with the pioneer work of Sédillot, of Pelière and Pénieres, the per-

fecting of a serviceable gastrostomy free from at least one of the two deficiencies of heretofore, must be given to Fontan.⁴ (Fig. 3.)

Recapitulating, Egeberg, must be given credit for first suggesting the possibility of using the operation for human alleviation and then to Sédillot for devising and perfecting an operative technic for actually doing the operation (although with certain deficiencies), and then to Fontan for having recognized the deficiencies and, in the course of working to overcome them, perfecting a technic for performing the operation in such a manner that the fistulous tract into the stomach had a valve-like mechanism at its stomach end which acted to prevent both leakage and seepage, thereby eliminating the distressing post-operative skin sequelae.

It must be credited to both Sédillot and Fontan that they recognized the high mortality they had experienced in performing the operation on humans as entirely out of line with the severity of the operation, and suggested that patients with esophageal stricture should be subjected to the operation early, not after a period of starvation when their natural body resistance had been reduced to nil; and what in the ordinary course of events might have been an infection thrown off by a body possessing normal resistance, became a rapidly progressing peritonitis with early death.

In 1930, with pleasure and intellectual profit, I paid a visit to Graz, in the province of Styria in Austria. Professor Denk was chief of surgery at the University. (This is the Prof. Denk who it is said, committed suicide on the day that the Nazis entered Vienna.) It seemed that a quaint custom had been conditioned into the young female contingent in that province (the bobby soxers, so to speak) that whenever the boy friend did not stand by his commitments, recourse was immediately had to a jar of lye, which was kept in all of the houses around the countryside in order to keep their stone floors and tiling clean, and a goodly portion swallowed. The result was

De la Gastrostomie par la méthode de la valvule ou du plissement de la muqueuse stomacale.

Par

L. PÉNIÈRES (de Toulouse)

Chargé de cours de pathologie externe à la Faculté de Médecine

Nous avons fait, il y a quelques années, des expériences sur les animaux dans le but d'éclaircir quelques points obscurs de la physiologie pathologique des organes creux de l'aliment.

Nos recherches avaient porté plus particulièrement sur les points suivants. Une plaie pénétrante à travers l'abdomen, les intestins et l'estomac ou l'intestin se présentent au fond de la plaie qui s'effritent exactement. Nous supposons, pour la facilité de la description, qu'ils ne font pas hernie. Dans ces conditions, la cicatrisation de la paroi abdominale ouverte par le trépan donne une cicatrice par une pièce de la paroi stomacale, par exemple, plus ou moins large suivant l'ouverture de la lésion, quand l'adhérence des deux sévères accolées aura fermé le fond de la plaie et rétabli la continuité de sa paroi.

Quel est l'avenir de cette pièce autoplastique de l'abdomen? Elle se rétracte en même temps qu'elle ferme la plaie et la muqueuse dont elle forme le fond et comme le diaphragme; mais cette rétraction est-elle égale dans toute l'épaisseur de sa paroi?

Quelle est la limite et l'étendue de la rétraction de la couche musculaire? La tunique musculeuse obéit-elle à ce mouvement, ou bien indépendante, dans une certaine mesure, de la tunique muqueuse, par suite de la limite de ses connexions, a-t-elle une allure propre et une vie particulière?

La réponse à ces questions ne pouvait être demandée qu'à l'expérimentation.

EXPERIENCES.

Chez un animal dont la région stomacale a été raide et rendue asynclonique, une incision de 6 centimètres est faite sur la paroi abdominale.

FIG. 4. Facsimile of Pénieres' contribution.

that Denk at all times had an unusual number of cases of stricture of the esophagus from the corrosive effects of the lye.

It was the rule in his clinic to do a gastrostomy on these cases, and to start feeding them as soon as they had recovered from the acute symptoms of the lye poisoning, which was generally in seven to twelve days, and he constantly advocated that the earlier the operation was done the better. In the cases of carcinoma of the esophagus it went without saying that the earlier the better, thereby harking back to the pleas of Sédillot and Fontan that they would have liked to do their operation under more favorable conditions before it was judged harshly and possibly discarded.

In discussing Fontan's contribution to the technic of the operation, mention was made of his use of the work of two con-

temporary French surgeons. Let us see what Pénieres contributed.

Pénieres' contribution was published in one of the Paris surgical journals in April, 1893, under the title "De la Gastrostomie par la méthode de la valvule ou du plissement de la muqueuse stomacale." It is of historical and bibliographical interest that this article, published in Paris in 1893, is the first published reference to the formation of a valve in the operative procedure. Fontan's article was published in the proceedings of the Tenth Congress of Surgery in France in 1896, three years after Pénieres' contribution.

In Pénieres' description of his operative technic he made it quite obvious that his efforts were directed toward preventing seepage and regurgitation of the gastric content through the gastrostomy on the stomach wall. An attempt will be made to

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elle a été pratiquée vingt fois déjà en Angleterre, en Amérique et en Allemagne (1), mais qui n'avait pas encore réussi, malgré l'habileté des chirurgiens qui l'avaient répétée. Il s'agit en un mot de la *gastro-stomie* conçue il y a près de trente ans par notre illustre collègue M. Sédillot, et que je viens d'être assez heureux pour mener à bonne fin dans une récente tentative.

Je ne vous cache point la satisfaction que j'éprouve en attachant ce nouveau fleuron à la couronne si riche déjà de la chirurgie française; mais je vous prie d'en rapporter beaucoup moins l'honneur à ma main qu'à la louable hardiesse de mes prédécesseurs que je n'ai eu qu'à imiter, ainsi qu'aux perfectionnements apportés à la médecine opératoire par nos contemporains, et que j'ai simplement transportés dans le domaine de la *gastro-stomie*.

Cette opération, je l'ai déjà dit, a été pratiquée vingt fois depuis 1849 jusqu'à nos jours, mais dans des conditions très-peu favorables, il faut en convenir. Le plus souvent il s'agissait de cancers de l'œsophage ayant amené un état cachectique dans lequel l'intervention chirurgicale réussit bien rarement: quelquefois on avait eu affaire à des rétrécissements non cancéreux, mais les patients étaient dans le marasme, condition qui n'est guère meilleure, quand le succès exige un concours actif du processus réparateur naturel, comme c'est le cas dans la plupart des opérations anaplastiques. Enfin, la lecture attentive des faits permet de croire que les procédés eux-mêmes ont été parfois défectueux.

Dans mes méditations sur les principes de la chirurgie réparatrice et sur les causes multiples des revers chirurgicaux, je n'avais pas oublié la *gastro-stomie*; jela trouvais logique comme opération, jela savais justifiée par l'histoire des fistules gastriques consécutives à certaines blessures, ou créées par les physiologistes dans leurs recherches sur la digestion stomacale. J'étais d'ailleurs persuadé que les échecs éprouvés jusqu'ici dépendaient moins du traumatisme que des conditions organiques des

(1) Au moment où je communiquais cette observation, je ne connaissais que 15 cas de *gastro-stomie*; des recherches bibliographiques plus complètes permettent d'élever à 20 le nombre des opérations. Au reste, une monographie complète est en voie d'exécution.

FIG. 5. Comments on Sédillot's contribution by one of his colleagues, Pelière.

follow the step by step modification and perfecting of the procedure, each worker attempting to overcome some obstacle, until gradually there is evolved the procedure as it is known today.

Pénières⁵ said that a valve composed of mucous membrane fulfilled its intended function when it prevented the escape of gastric juice. He believed that he had accomplished this by the technic which he described, in that following operation there had been neither inflammation nor ulceration of the skin, proving thereby that the gastric juice had been confined to the stomach and had been unable to escape therefrom. (Fig. 4.)

Pelière was an experimental pathologist.

M. Pettit de la Villéon. — Mon ami Pauchet vient de dire un mot qui, certainement, a dépassé sa pensée. Il est un chirurgien trop averti pour ne pas le reconnaître lui-même. Il nous dit: « Le procédé de *gastrostomie* de Depage, de Bruxelles, est le seul procédé réellement continental. »

Je me fais alors un devoir de rappeler une excellente méthode et de prononcer un nom auquel, ces jours derniers, des Sociétés savantes: Société Nationale de Chirurgie, Académie de Médecine, ont rendu un hommage justement mérité. Je veux dire: le Professeur Fontan, le grand chirurgien, le merveilleux enseignant de l'École de Toulon, dont j'ai eu le grand honneur d'être l'élève. Années inoubliables de ma formation chirurgicale!

Vous connaissez son procédé de *gastrostomie*, en valvule, en « mitre d'évêque », comme il disait. J'ai eu plusieurs fois l'occasion de l'aider dans cette opération et nous avons suivi ces opérés. Eh bien, je vous assure que ces *gastrostomies* étaient continentales, que ces malades ne conservaient en place ni sonde, ni appareil. Ils avaient la sonde dans leur poche, avec le petit entonnoir en verre et ils ne mettaient le tout en place que pour leurs repas.

Faites le procédé « en mitre d'évêque », de Fontan, tel qu'il l'a imaginé, tel qu'il est resté, et vous aurez des bouches continentales.

Vous comprendrez, Messieurs, que je saisisse cette occasion qui m'est offerte de prononcer aujourd'hui, en cette enceinte, avec une émotion respectueuse et reconnaissante, le nom de mon vénéré Maître, du grand chirurgien français qui vient de disparaître, et d'associer ainsi la Société des Chirurgiens de Paris au juste hommage que des grandes Sociétés savantes viennent de rendre au nom de Fontan.

L'anesthésie interrompue en chirurgie gastrique

par M. L. HARTLORI.

Je présente cette communication, au nom de l'un de mes assistants, le Dr Brzeziński, anesthésiste de mon service, et en mon nom personnel.

Tout anesthésiste averti sait qu'au cours d'une opération tant soit peu importante, la dose d'anesthésique à donner au malade ne reste pas constante. L'idéal auquel on doit tendre, c'est de donner au malade le minimum d'anesthésique sans que le chi-

FIG. 6. Facsimile of comments on Fontan's contributions by one of his colleagues.

He was interested in the problem technically and in the perfection of the procedure, but more in the nature of an experimental piece of laboratory research than in a technic for human adaptation; although he fully realized the uses for such a procedure. His work, therefore, was confined to laboratory research, experiments on dogs, and he did no operations on the human body. (Fig. 5.)

Fontan,⁴ in his article, was careful to acknowledge the preliminary contributions of both Pelière and Pénières, and to indicate that his method differed from any other hitherto advanced, in that whereas his predecessors had made their valve from the mucosal lining of the stomach alone,

he made his from all three layers of the stomach wall including the serosa, and he had every reason to believe that it would be stronger in construction and therefore function better, which it evidently did.

That the procedure was satisfactory, not only to Fontan himself, but to his associates and assistants, is attested to by the fact that almost forty years later one of his early assistants, in a discussion of Dépage's technic for gastrostomy, got up and defended Fontan before the august Society of Surgeons of Paris, at one of its meetings, against the previously enunciated eulogy of Dépage by M. Pauchet. Dépage was then at the height of his fame and position in French surgery, particularly Parisian surgery, and indirectly in the process of claiming also some part in the origination of the technique then known.

The following is taken from the "Bulletin et memoires de Société de Chir. de Paris, vol. 32, March 6, 1931, and was by M. Petit de la Villeon.⁶ (Fig. 6.)

Along about the early nineties the operative procedure was attracting attention in America, and American surgeons were adding their efforts toward perfecting the technic. The surgical literature tells us that the first gastrostomy done in America was by a Philadelphia surgeon named Maury. Although the result was not successful, Dr. Maury was impressed with its possibilities and said: "So great is my conviction that the procedure is justifiable that I would have no hesitancy in resorting to it in any case of impending starvation from non-cancerous stricture of the esophagus, provided malnutrition had not reached a stage which rendered the case hopeless."

In 1894, Edmund and Willys Andrews,⁷ professors of clinical surgery at Northwestern University, published an account of their research and study and clinical experience with their own technic of a gastrostomy made with a mucuous membrane lining.

The first successful gastrostomy—that is, wherein the patient lived after operation—was done in 1876, by a surgeon

named Verneuil.⁸ In his description of his technic and report of his success he searched the literature, and up to that time he was able to find twenty autopsied cases in which the operation had been done, but not a single successful case.

However, this can be explained on the basis that practically every case up to that time had been done for malignant obstruction of the esophagus on patients badly depleted by the disease and offering very poor surgical risk, whereas, in his successful case it had been done for a non-malignant stricture in a patient presenting a fairly average degree of risk only.

One arrives now at a stage in the development or evolution of a technic which is rather the usual in almost all scientific efforts. The need for a procedure has forced its discovery, then drawbacks in its original conceptions have forced men to seek better, more perfect ways in which to make the procedure more adaptable and with a greater degree of safety to the human individual needing such a procedure. Therefore, we have attained successfully the following steps in procedure: first, the establishment of the indications for such an operation as gastrostomy; secondly, origination of a technic for performing that operation; and for these first two steps we must give full credit to Egeberg in Norway, and Fontan in France.

The next step is the elimination of defects present in the technic up to that time, most prominent being the problem of leakage and skin digestion about the attachment of the gastrostomy fistula to the skin. So we find men devoting their attention to the development of valvular arrangements in order to render the valve tight and avoid leakage. Historical accuracy demands that we must give full credit to Pénieres⁹ and Fontan⁴ for a satisfactory solution of this phase. The associated handicaps of peritonitis and infection were to be remedied not strictly by anyone directly associated with the task of making a better gastrostomy, but by the development of antiseptic surgery by Lister

Résultats d'une nouvelle méthode de gastrostomie, 6 observations,

Par M. le Dr DÉPAGE,
Chirurgien à l'hôpital St-Jean de Bruxelles.

Dans le courant de l'année 1901, j'ai publié un nouveau procédé de gastrostomie qui m'a paru présenter des avantages sérieux sur les autres procédés en cours.

Le principe de la méthode consiste à créer, aux dépens de la

FIG. 7. Facsimile of title page of Depage's contribution.

and indirectly by those men who were doing gastrostomies, recognizing that their chances for success were greater if the operation were done earlier, whether in cases of stricture of the esophagus following ingestion of corrosives or from malignant disease.

That brings us into a new phase in the development of the operation—a stage characterized by refinements in technic—the development of technical approaches aimed at simplifying and shortening the time of performing the operation, attempts at making the tightness and efficacy of the valve construction more certain, and also attempts at correcting some of the more minor flaws still present in the operation.

We come now to a series of names more or less familiar in the field of gastric surgery, names such as Von Hacker,⁹ Witzel,¹⁰ Stamm,¹¹ Kader,¹² Marwedel,¹³ and Dépage in France.

Ending this list of names with that of Dépage is done with a purpose, as this comprises the period which was devoted to refinements in the technic as mentioned above, aimed at performing a better operation in quicker time and with resultant increased benefit to the patient. (Figs. 7 and 8.)

Von Hacker's contribution consisted of bringing up a portion of the anterior wall of the stomach through the fibers of the rectus abdominis muscle and hoping that the pressure of this voluntary muscle would act as a valve and keep the gastrostomy leak-proof. His tube was lined with stomach mucosa and had the drawback that it often tended to close and also that the compres-

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quelques chirurgiens; elle présente, comme nous nous en sommes tous rendu compte, le grave inconvénient de permettre au suc gastrique de s'écouler au dehors et de venir ulcérer la paroi du ventre. On a imaginé nombre de procédés pour obvier à ce défaut; citons les méthodes de Terrier, de Witzel, d'Isbancjew-Frank, de Fontan, de Poncet, de Marwedel, etc. Pour ma part, j'ai eu recours, de préférence, pendant ces dernières années, au procédé d'Isbancjew-Frank; deux fois j'ai employé la méthode de Marwedel.

La méthode d'Isbancjew-Frank m'a réussi la plupart du temps et j'ai eu l'occasion d'insister sur ses avantages dans un article paru dans le *Journal médical de Bruxelles* (1). Plusieurs de mes malades, cependant, n'ont pas retiré de ce procédé le bénéfice que j'en attendais. C'est que, il faut bien le dire, le tunnel que l'on est censé créer dans la paroi abdominale aux dépens de l'estomac, est purement théorique. Si même ce tunnel existe au début, au bout d'un certain temps il s'efface, et l'opération d'Isbancjew-Frank se réduit dès lors, comme résultat, à la gastrostomie de Terrier. C'est l'étroitesse de l'orifice externe qui, seul, empêche le suc gastrique de s'écouler au dehors, et il suffira que cet orifice soit d'un diamètre un peu trop grand ou qu'il se laisse corroder dans une certaine mesure, pour qu'immédiatement le contenu de l'estomac puisse s'échapper.

Le procédé de Marwedel présente d'autres inconvénients. Comme je viens de vous le dire, je l'ai employé dans deux cas. Voici les résultats de mes opérations :

Un premier malade, opéré par mon aide, le Dr Marcelle, a parfaitement guéri au point de vue opératoire. Il est sorti de l'hôpital au bout de deux mois. Dans la suite, la déglutition s'étant considérablement améliorée, le malade abandonna, malgré nos avertissements, la sonde stomacale et se remit à prendre des aliments par la bouche. Comme il fallait s'y attendre, bientôt les difficultés de la déglutition se reproduisirent, mais malheureusement, lorsque le malade voulut replacer la sonde dans l'estomac, la fistule était cicatrisée. On dut réintervenir, mais cette fois, le procédé de Marwedel n'était plus possible: il fallut se contenter de pratiquer une simple fistule. Celle-ci ne put retenir le suc gastrique; elle se transforma en un véritable cratère et mena rapidement à une issue fatale.

(1) Dr DÉPAGE.

FIG. 8. Facsimile of the gist of Depage's remarks.

sion action of the rectus fibers was not all that Von Hacker expected, and he still had considerable wound and skin difficulty. Von Hacker's work was done in Vienna between 1884 and 1890. Finsterer, who had been Von Hacker's pupil and later his assistant as late as 1930, to my knowledge, performed all gastrostomies according to Von Hacker's technic, despite his frequent postoperative grief. His argument was that he could do it cleanly and quickly; therefore, he preferred it, although in doing a

Centralblatt für CHIRURGIE

herausgegeben

E. von Bergmann, F. König, E. Richter,
in Berlin. in Göttingen. in Breslau.

Achtzehnter Jahrgang.

Wöchentlich eine Nummer. Preis des Jahrgangs 20 Mark, bei halbjähriger Pränumeration. Zu beziehen durch alle Buchhandlungen und Postanstalten.

No. 32.

Sonntag, den 8. August.

1911.

Inhalt: I. Witzel, Zur Technik der Magenfistelanlage. — II. Kelliker, Witzelsche für Oesophagusfisteln. (Original-Mitteilungen.)
1) Gieseler, Lymph. — 2) Beyerthal, Menstruation traumatisch. — 3) Schellbo, Fehlbildung bei Mittelobereinklung. — 4) Haug, Lymph und Nephritis bei Obstruktion. — 5) Zausel, Fremdkörper in der Pankreas. — 6) Schell, Zahnstücken. — 7) Camder, Atresie der Singlone. — 8) Fegmell, Anthropologie bei Laparotomie. — 9) Hinkelstein, Frakturklemmung. — 10) Wegel, Kollisionsbehandlung der Leistenbrüche. — 11) Zacherwald, Brüche im Inguinalraum. — 12) Fort, Harnkreisläufe. — 13) Schlichtschaw, Nierenkreisläufe. — 14) Gieseler, 15) Bursitis, Hysteresis. — 16) Blau, Gekrötenkreisläufe. — 17) Kelliker, Hysteresis der Nierenkreisläufe. — 18) Ribbert, Komplexionische Hypertrophie der Geschlechtsdrüsen.
19) Kasperl, Antifisteln. — 20) Pillerich, Aspirator-Injektion. — 21) Hesse, Beiträge zur Chirurgie. — 22) Kummer und Christl, Tuberkulose der Lunge. — 23) Kelly, Kropf. — 24) Ransom, Fremdkörper im Kehlkopf. — 25) Coes, 26) Cohen, Bruchkreisläufe. — 27) Steiner, Lymph der Pforten. — 28) v. Benda, 29) Fuchs, 30) Wladar, Harnkreisläufe. — 31) Wolf, Kollisionsoperation der Pforten. — 32) Koch, Fettgeschwülste im Hohlraum. — 33) Bröwe, Harnkreisläufe. — 34) Casali, Gebärmutterkreisläufe. — 35) Krystal, Aneurysma der A. subclavia. — 36) Pohl, Exstirpation des Schilddrüsen. — 37) Demareille, Mischbildung der Hand. — 38) Wolff, Arteriosklerose. — 39) Benda, Mit perforiert.
II. Dermatologen-Kongress

I. Zur Technik der Magenfistelanlage.

Von

Prof. Oscar Witzel, Bonn.

Die Mitteilungen über die Anlage einer Ernährungsfistel am Magen sind in der letzten Zeit seltener geworden. Die Operation ist in die Reihe der allseitig als berechtigt anerkannten und vielfach geübt eingetreten, und es steht auch statistisch fest, dass durch dieselbe positiv Nutzen geschaffen wird. Dennoch schreitet wohl kein Chirurg ohne ein gewisses Zögern zur Ausführung derselben, sofern es nicht gilt, den unmittelbar drohenden Erschöpfungstod abzuwenden. Dieses Zaudern ist bedingt durch die Unsicherheit des

FIG. 9. Facsimile of title page of Witzel's article on gastrostomy. (Note date of publication.)

jejunostomy or an enterostomy he used the Witzel technic.

The Witzel technic (Fig. 9) is familiar to all interested in gastric surgery and hardly needs any detailed description here. Suffice it to say that the canal by this procedure is lined with serosa and tends to obliterate and close.

Next followed a flurry of ideas along two different lines, but both directed toward the same objective the avoidance of leakage and making the gastrostomy tube fluid tight.

The first group tried using the highest fibers of the rectus muscles for compression; and another group tried to bring up a tent of the anterior wall of the stomach through the costal cartilages and to use

the actual squeezing and compression power of the cartilages or of intercostal muscle fibers to accomplish their end. These naturally were outcroppings of Von Hacker's first ideas; all were serosa lined with the already named serosal deficiencies.

Another group built their gastrostomy technic around a tubular valve and purse-string sutures, varying Witzel's method a bit by the manner in which they inserted the tubes; and here we find men putting in two purse-string sutures, one above the other and calling it a new operation and that two sets of valves were formed by this method, and then others putting in three purse-string sutures, one above the other, also calling it a new technic, a new operation, and that better and more efficient

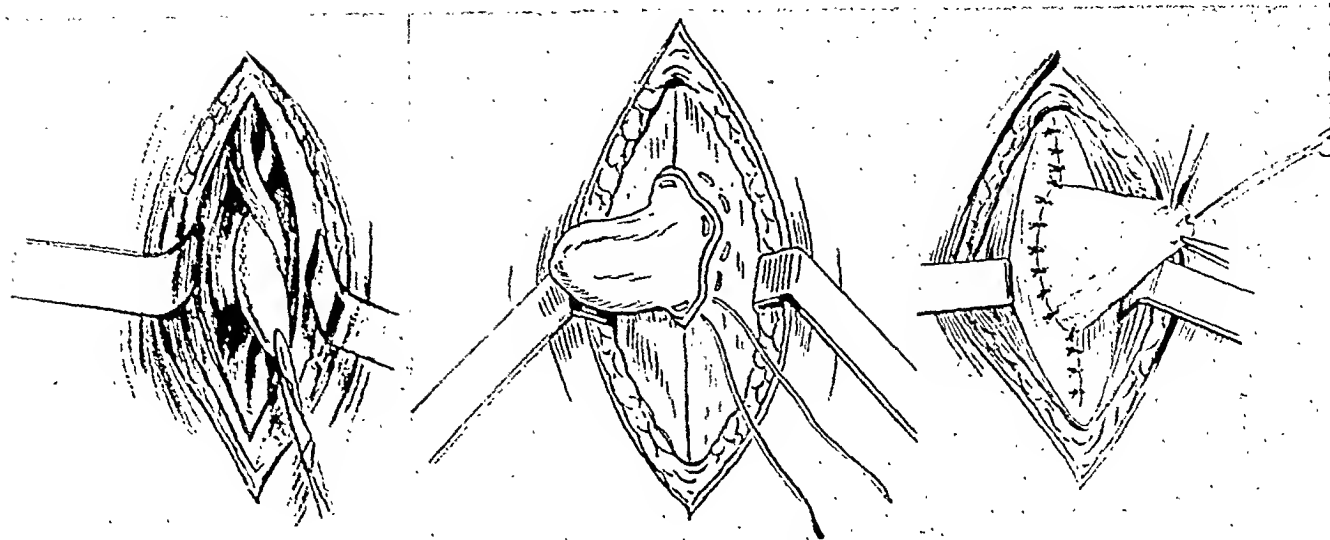


FIG. 10.

FIG. 11.

FIG. 12.

FIG. 10. Gastrostomy as "originated" by several surgeons attempting to use the longitudinal rectus abdominus fibers as a constricting force notably one Girard, a French surgeon.

FIG. 11. Gastrostomy as advocated by another Frenchman consists of bringing a cone of the stomach through the split rectus abdominus, wishfully hoping that the constricting action of the rectus muscle would counteract spillage and leakage.

FIG. 12. An illustration from articles by various French surgeons, wherein the procedure of bringing a cone of anterior stomach wall through the rectus was utilized. (So many names are attached to this particular procedure, that the number is too great to enumerate here.)

valvular action had been achieved. It is readily admitted that in all of these technical approaches leakage and spillage had been overcome to varying degrees.

These were the methods of Stamm, Kader, Marwedel and Heussner, representing only one man's idea of doing another man's operation, which brings the subject up to Dépage's¹⁴ contribution in 1901.

Inasmuch as Dépage's contribution to the technical progress of the gastrostomy operation constitutes a sort of milestone, it might be well to recapitulate what had taken place up to his time in development of the procedure.

Egeberg, who first proposed the operation in a lecture before a medical society, in Copenhagen, gets and is entitled to credit and priority for his part. Next, a technic was developed by experimentation with animals and that the operation was then done on humans with at first invariably fatal results; but finally a few successes by various surgeons were reported. For this phase the French surgeons, Pénières and Fontan receive priority and credit. The next steps were refinements of technic proposed by various men to over-

come deficiencies, such as infection within, peritonitis, wound infection and digestion of tissue because of non-continnence or faulty continence of the tube.

To the two Frenchmen, Pénières and Fontan, must be given credit for evolving a water-tight and continent valve-like arrangement.

Then came more procedures, all directed toward circumventing this incontinence. We find men bringing up a tent of anterior wall of the stomach through rectus abdominis muscles, hoping for satisfactory voluntary pressure control; then other men bringing a similar segment of stomach wall out through the lower intercostals with the same objective in view, in other words, trying to solve the problem of continence of the tube, it being paramount that it should be water-tight.

Still another deficiency was present, however, the early closure of the fistula tract by the walls coming together and healing so that sounding and dilatation were later necessary; and when such was necessary, the old problem of continence popped up.

So we come to various men originating tube formations lined with mucosa.

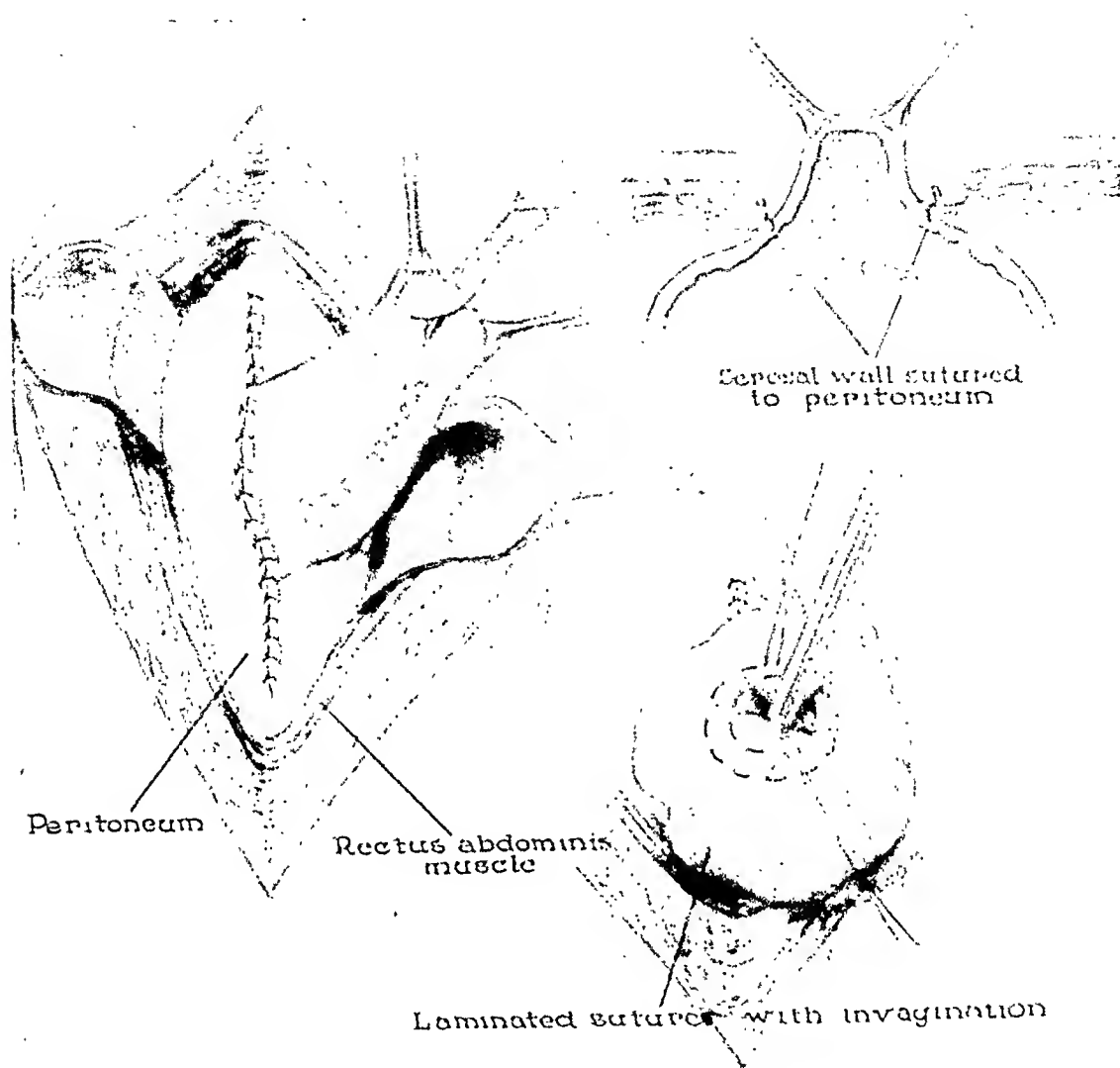


FIG. 13. Methods used for overcoming leakage and spillage.

Dépage¹⁴ contributed the tube features of a continent and functionally efficient gastrostomy, and should be given credit for it even though an American, Janeway, apparently working on the same procedure, presumably with no knowledge of the other's work, came forth in 1913 with an almost identical technique, announced as a new one.

Janeway's¹⁶ article appeared not in an American Journal, but in the *Münchener Medizinische Wochenschrift* in 1913, twelve years after Dépage's original article. Priority seems rightfully to belong to Dépage.

One dislikes to write the following, but obeying the precepts of "science knows no geographical boundaries" (perhaps we

should add "nor ethnological or racial ones either"), it was a Japanese surgeon, Watsudjii,¹⁷ who really first combined a tube and a valve technique and deliberately wrote that he had done so, although he varied his technique a little in order to satisfy his sense of originality, and as Von Hacker had only recently announced his contribution to the technique of the operation, the Japanese surgeon put two and two together in the form of the Von Hacker advocated method of bringing up a portion of anterior wall of stomach through the abdominalis rectus muscle (the only feature distinguishing Von Hacker's method from any other) and then making a valve as originally de-

ed by Fontan. He obtained thereby a
ned continent gastrostomy, and he
ished his technic and results in 1899,
in a Tokyo medical journal. *To the Jap
surgeon's credit, he gave credit to Von Hacker
and Fontan cren, in his title for his article.*

Dépage published two articles describ-
ing his gastrostomy technic—one in a
Brussels surgical journal in 1901, "A New
Method or Procedure for Doing a Gas-
trostomy"—then two years later, in 1903,
followed with another article in a French
Journal of surgery and titled—"Results
with a New Method of Gastrostomy."

What Dépage had contributed to the
procedure was that he formed a rather
elongated fistulous tube from the anterior
wall of stomach in such manner that the
entire tube was lined with mucosa.

There were weaknesses in this planned
technic as will be pointed out.

At almost the same time Janeway an-
nounced an almost identical technic, to the
extent that there being some question as
to who antedated who, and as priority
could not be accurately determined, it was
designated as the Dépage-Janeway method
and was so called after that time.

Janeway brought out many technical
factors of interest and gave the reasons as
to why he was trying to overcome each
and then how he had rationalized his
technic toward such an end.

First, he was definitely of the opinion
that a tube constructed from the anterior
wall of the stomach was best from the
standpoint both of continency and spillage
over the skin, and he was aware that in
a certain percentage of cases the fistula
healed and had to be dilated or plastic pro-
cedures for opening it again considered.

Secondly, he was also definitely of the
opinion that the tube should be constructed
from the body of the stomach, not from
the pyloric antrum, and that it should be
placed high toward the cardia if such were
feasible as in his experience leakage was
more common when the procedure was
attempted lower down in the stomach.

Thirdly, in carcinoma of the esophagus

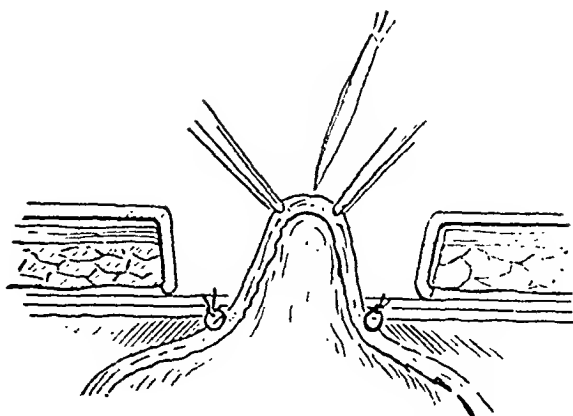


FIG. 14. An illustration from articles by various French surgeons, wherein the procedure of bringing a cone of anterior stomach wall through the rectus was utilized. (So many names are attached to this particular procedure, that the number is too great to enumerate here.)

delay in performing gastrostomy was
deadly and to wait until a patient was
totally dehydrated and suffering from star-
vation was absolutely inexcusable. His
argument was: What can you offer a pa-
tient suffering from carcinoma of the esoph-
agus other than gastrostomy? You can
dilate, and this only with risk at any stage
of the disease process, or you intube under
equally risky circumstances, but after you
do this for only a very short time the pro-
cedure is too painful for the patient or
severe hemorrhage occurs to the point
where patients may die while you are
attempting to get past the lesion with your
instrument.

Fourthly, in spite of possible leakage,
skin excoriation, and closure of the gas-
trostomy fistula there are many advantages
to the patient and this technic reduces the
above disadvantage to a minimum.

It seems that to men of many nations
must be given some credit for attempting
to solve gastrostomy difficulties. Among
these were three Russians at different
times. Bassow, of Moscow, and Blondlot
in the early days. One Trofimow, in 1898,
suggested turning the stomach flap in such
manner that the serosa formed the internal
lining.

It is only fair to say here that although
the published technic of Dépage and Jane-
way from the standpoint of priority carry

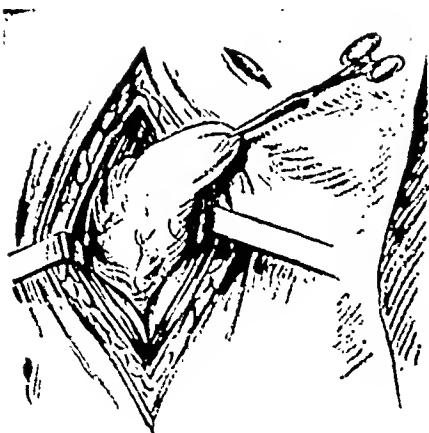


FIG. 15.

FIG. 15. An illustration from articles by various French surgeons, wherein the procedure of bringing a cone of anterior stomach wall through the rectus was utilized. (So many names are attached to this particular procedure, that the number is too great to enumerate here.)

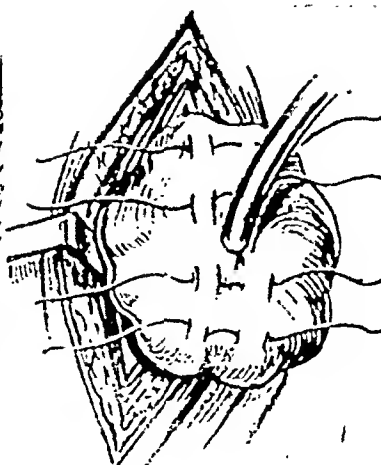


FIG. 16.

FIG. 16. Gastrostomy according to Kader's method. The scene now changes to the procedure of invagination and the use of either a metal or rubber tube.

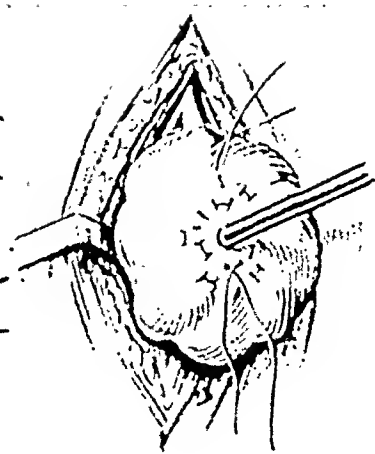


FIG. 17.

FIG. 17. Gastrostomy according to Stamm's method. The scene now changes to the procedure of invagination and the use of either a metal or rubber tube.

the following dates—Dépage, 1903 and Janeway's work did not appear until 1913, the reason for the ten-year interval and yet their joint priority credit is not satisfactorily explained.

At any rate to recapitulate to date: Fontan originated the valve idea of the technic and Dépage originally fathered the idea of a tubular fistula. Then along came a Japanese, Watsudjii¹⁷ and combined the two procedures and published his article in 1899, and in all fairness to him should be given the credit of first combining the two procedures.

After Dépage, there was still some dissatisfaction with the technic of the operation and we find many famous names involved in efforts toward perfection.

Senn,⁸ of Chicago, added his name to the already long list by proposing in 1896, a circular valve method which was nothing new on Fontan's original idea but rather a semi-reassertion of the same idea. The thought occurs here, was this a contribution or merely the getting into print, which is easy for an illustrious name.

The extent and scope of the procedure described to accomplish a gastrostomy were and are to say the least truly amazing. In 1906, again with that title which

repeats itself so often. "A New Method Of Gastrostomy" in a French Surgical Journal, one man describes how he resected about six to eight inches of jejunum, left this section attached to its mesentery, then anastomosed one end to the stomach and the other end he brought out through the skin and attached it to the skin.

Shortly after Witzel¹⁰ announced his technic, which gave a tube lined with serosa, there came a flood of articles all more or less titled "A Modification of the Witzel Method of Gastrostomy," in which was argued the point that a catheter of smaller caliber than the one recommended by Witzel was obviously better and then, just as vehemently another article would appear arguing that a catheter of much greater caliber gave a much better result.

Amazing also is the roster of names connected in some way with gastrostomy technic because of its numbers. It would not be to any point to name all in an article such as this, but in addition to those already mentioned, Ullman, Frank,¹⁹ Jaboulay²⁰ and Jianu²¹ are worth retaining in memory, particularly Frank and Jaboulay because the technic advocated by these two is rather identical so that

the procedure is usually described as the Frank-Jaboulay method, thereby carrying the names of both originators.

Professor Denk, in Vienna, constantly mentioned Czerny in connection with any discussion of gastrostomy, and spoke of a Czerny method or technic. Presumably, Czerny had been Denk's master and teacher and he took the occasion to attach the name of his old professor in admiration and reverence. At any rate a search of the bibliography does not show that Czerny at any time wrote or published an article on the subject. We proceed onward through the various stages of variation in the advocated technic, through the metallic cannulas, a sort of take off on the Murphy button with a long shank or neck between the two anastomosed buttons, so that the actual fistulous tract was metallic, *if the sutures held.*

Coming up to contemporary times we find mentioned in the literature the Jianu technic and the names of men active in contemporary surgery. *Most employ the term tubo-valvular gastrostomy which is anatomically, adequately descriptive.*

In 1931, Pauchet,²² of Paris, published an article entitled "Tubular Gastrostomy." In 1933, George Pack²³ of the Memorial Hospital in New York, published two articles relative to the Jianu technic.

Spirack's²⁴ Gastrostomy is a Janeway-Dépage-Fontan operation in that Dépage contributed the tube idea many years before Spirack had appeared on the surgical scene and the same goes even more so, for the valve principle of Fontan, whom we must not let be pushed into the background and ignored because of a lack of defenders of his priority. Equally so must Watsudjii not be forgotten who was first to describe and combine two operations (Fontan and Von Hacker's) many years before Spirack, but one has only to cite the literature in chronological time and Fontan, Dépage and Watsudjii win the case.

Thorek²⁵ laments the lack of appreciation of the pioneers in gastrostomy. The findings of his exhaustive study on gas-

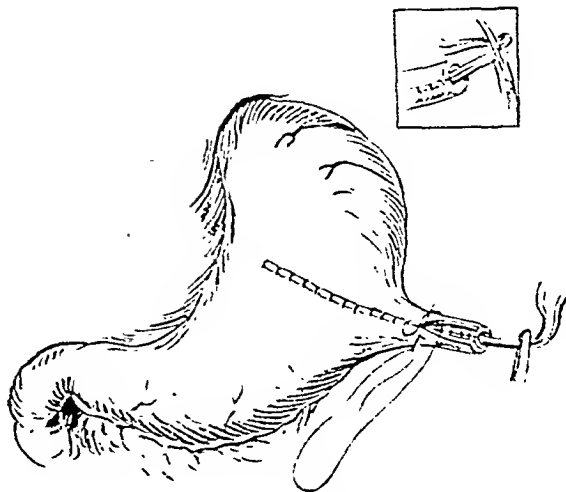


FIG. 18. Dépage's operation combining the principle of the tube and valve.

trostomy are supported by Ferrari and Iturrapse,²⁶

But let Thorek be comforted. The great Osler one day had an article published describing the Mickulicz syndrome in the mouth relative to Stenson's duct with the occlusion and backing up of secretion into the parotid, but Osler actually made the statement that to his knowledge the syndrome had never been described before.

To Mickulicz' credit it must be said that he did not challenge Osler's statement but others did and great must have been Osler's embarrassment to find that Mickulicz had published his experiences with the same syndrome and had described it in an article only a few years before.

To go back to the Jianu technic for a moment. Jianu's original article appeared in 1912, in the *Deutsche Zeitschrift für Chirurgie*. It represents in reality the results of some experimental surgery done by Beck and Carrell on dogs, here in America, at the Rockefeller Institute.

The technic of this operation has many admirable recommendations. First, is that the plastic feature on the stomach is less difficult and less prone to postoperative complications at the stomach end. Dr. George Pack of the New York Memorial Hospital, favors this operation because he is so often confronted with the problem of a plastic rebuilding of a lower end of esophagus after resection for carcinoma and it lends itself best to such a purpose.

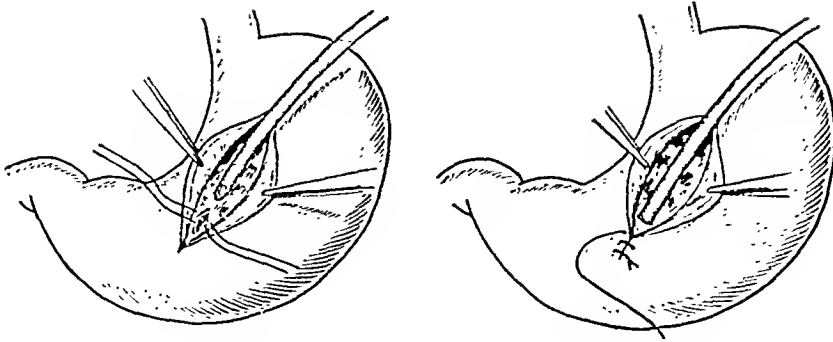


FIG. 19. Technic and procedure of Marwedel.

Pack also points out that the technic is not difficult and the hazard to the patient, always a poignant factor in Pack's mind, is definitely less.

This is a somewhat similar technic. At least the principles are the same as the plastic reconstruction of a cut ureter where the amount available for implantation into the bladder is short.

Pack stresses some important points in the technic conducive to success: (1) The lumen of the tube should be 1 inch or more in diameter. (2) Tension on the tube by the pulling of a weighted stomach after food intake requires anchoring the stomach to the abdominal wall as securely as possible.

A gastrostomy contemplated as a permanent fixture or addition to the human economy should fulfill certain objectives fully and completely. These objectives are relatively obvious and go almost without saying, yet it was the striving for perfection in one or more of them that led to the final technics which we know today: (1) There should be no leakage from the stoma, thereby, avoiding excoriation of skin; therefore, some type of closure mechanism, a sphincter or a valve, is necessary to prevent this excoriation. (2) The lining walls of a gastrostomy should be of such tissue as will not become adherent, thereby causing closure of the fistula necessitating either bouginage and dilation or a secondary operation. (3) Clinical experience has determined that the gastric end of the tube functions better the farther away from the pylorus it can be made. (4) The canal should be as long as

possible so that a feeding tube can be inserted for some distance. (5) The canal should bend (a bit of tortuosity is desirable) as it prevents regurgitation.

Fluids may be taken by mouth concomitantly with a gastrostomy, thereby giving the patient some degree of retention of taste-swallowing and the agreeable presence of something in the mouth. As in peptic ulcer—or analogous to the situation in ulcer—any degree of by-passing leads to a marked diminution of edema and inflammation about the lesion so that a patient finds himself able to swallow soft solids with greater ease, thereby opening up to him a new vista of food possibilities and from a psychotherapeutic angle the patient is happier even if this phase may be only temporary.

Although the Witzel method worked well in a jejunostomy or ileostomy, it does not work as well when applied to the stomach.

Marwedel's method differed from Witzel's only in that the first step is a puncture wound in the anterior wall of the stomach and inserting a rubber catheter therein, then holding it in place by means of a purse-strung suture; next making an incision in the seromuscular layer, laying the catheter along in this incision track and suturing the opposite cut edges of this seromuscular layer over the catheter in such manner as to construct a fistulous canal.

The technical method advocated by Senn, differed only that several purse-string sutures were placed, each a little wider and larger than the previous one, so

on drawing each together a deeper invagination was obtained.

It is difficult to award much credit to either Marwedel or Senn, particularly as to any originality in their modifications of Witzel's procedure.

Using a portion of jejunum or colon to manufacture a tube is extremely difficult technically and carries with such a procedure an extremely high mortality from infection.

Dépage, in 1901, published an article outlining the following technic. He cut out a rectangular flap of stomach wall through all layers—leaving the base parallel to the lesser curvature of the stomach and not cut or sectioned. Rolling and suturing the cut edges of this flap to form a tube, then attaching the distal end to the skin, completed the operation.

Modernizing this technic as of today presents some advantages.

It can be done under novocaine anesthesia. The anterior wall of the stomach can be delivered through a relatively small abdominal incision in such manner that the operation can be done entirely outside of the abdomen.

Janeway merely turned the operation around—so that the base paralleled the greater curvature instead of the lesser and thus was born another "New Method of Gastrostomy."

In a search through the bibliography of gastrostomy, one finds twenty-six articles on the procedure—all titled: "*A New Method of Gastrostomy.*" Janeway believed he had to put forth some claim as to the superiority of his operation over Dépage's, so he claimed that his suture line being on the upper surface of the newly made canal was less subject to strain and that his technic gave a better blood supply as it was derived from the greater curvature of the stomach, whereas, Dépage's was from the lesser.

The Jianu technic can best be described by a diagram.

The advantages of this method as practiced and described by Dr. George Pack

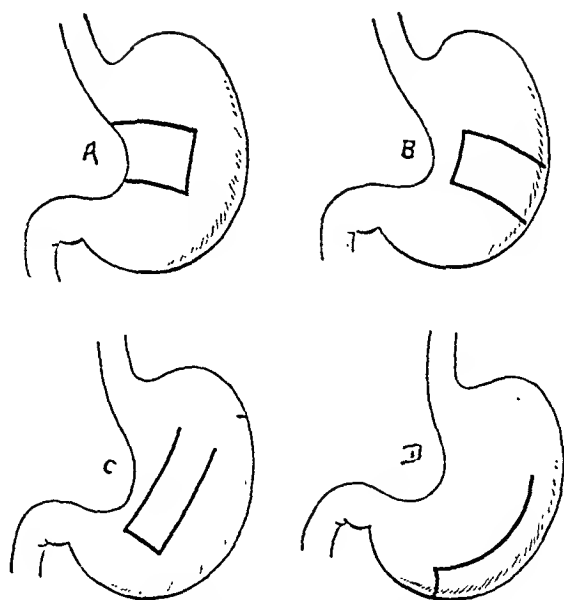


FIG. 20. Illustrating how several authors by adapting a different area for the same procedure but with little variation in technic manage to attach their names to the procedure of gastrostomy: A, Dépage's method; B, Janeway's method; C, Hirsch's method; D, Jianu's method.

are: (1) The external end is brought out to the skin so high that the possibility of regurgitation is markedly limited. (2) Subcutaneously it burrows under the superficial tissues and rectus muscle in such a manner as to take advantage of whatever voluntary compression there may be and the rectus may act as a sphincter. (3) Bending the tube upward accomplishes the function of a valve. (4) The lumen resulting is often of sufficient caliber to allow administration of semi-solid food.

Dr. Carl Beck²⁷ with Alexis Carrell developed a gastrostomy wherein a tube was made from the greater curvature of the stomach. The work was entirely experimental—done on dogs—but was presented before the Chicago Medical Society. Beck and Carrell should have more credit even than Jianu for originating this procedure but the operation was described as a prethoracic esophagus and the article remained hidden for years because published under such a title.

Dépage had advocated the same technic as Jianu or Beck-Carrell in cases of urinary retention, namely, the making of a fistula

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Gastrostomie und Ösophagoplastik.

Von Dr. Amza Jianu, Dozent an der med. Fakultät zu Bukarest, Assistent an der ersten chirurgischen Klinik.

(Mit 7 Abbildungen.)

Die unmittelbaren Vorteile der Gastrostomie bei vorgeschrittenen Narbenstenosen und beim Ösophaguskrampf werden nicht mehr bestritten, insbesondere wenn man die Anästhesie der Rückenmarkseinspritzungen anwendet. Es wird hierdurch der chirurgische Chok vermieden, der nach Gebrauch des Chloroforms so oft bei Kachektischen auftritt.

Egeberg (4) war der erste, der im Jahre 1837 die Gastrostomie bei den unteren Ösophagusstenosen vorgeschlagen hat. Dieser Eingriff ist von Blandin (2) (1841) und Bassow (1843) an Hunden vollführt worden, am Menschen von Sédillot (29) und Nélaton (1843). In der Folge veröffentlichten Fenger (5), Forster (8), Sidney Jones (32), Lane (21), Verneuil (36) Fälle, in denen nach der Technik Sédillots eingegriffen wurde. „Es wird eine Incision von 8–10 cm parallel dem linken Rippenrand gemacht; sie beginnt 5–6 cm nach außen von der Medianlinie, um nicht den M. rect. zu incidieren. Es wird ein konisches Stück des Magens herausgezogen und an den Wundrändern fixiert; an der Spitze des Magenkegels wird ein möglichst kleines Orificium angebracht; während der ersten Tage wird eine dauernde Nélatonsche Sonde eingeführt, später nur während der Ernährung.“

Die immer wieder vollzogene Einführung der Sonde vergrößert das Orificium der Fistel derart, daß die Fistel nichts mehr zurückbehalten kann. Infolgedessen sind verschiedene Verfahren erfunden worden mit dem Bestreben, dem fistulösen Magenkegel einen Schließmuskel zu verschaffen. So das Verfahren von Hacker (12), Girard (11), Howse (17), Terrier und Gosset (34), Hartmann (14), Jaboulay (18), die sämtlich den M. rectus zur Bildung des Schließmuskels verwenden. Um die Continenz der Gastrostomie zu sichern, kreuzt Girard einige Fasikel des M. rectus in S-Form.

Zum gleichen Zweck schlägt Hahn (13) einen schrägen Fistelkanal vor. Er macht zuerst eine dem Rippenrande parallel laufende Incision und

25*

FIG. 21. Facsimile of title page of Jianu's original article advocating his procedure.

from the urinary bladder out to the abdominal wall.

From the standpoint of overcoming leakage Senn's operation was a great improvement. Sometimes he sutured the base of his cone to the parietal peritoneum to overcome the pulling action of the stomach.

SUMMARY

Among the writing craft there exists a motto: "If you steal from one author, it is plagiarism; if you steal from many, it is research."

In the realm of psychology probably lies the explanation of a type of conduct one finds so consistently present in the evolution of some particular surgical technic. So consistently and even persistently does one find it that it cannot by any chance be attributed to mere coincidence.

To the non-psychologist, but one having

some experience in the detached scrutiny of the ways of human conduct there is only one explanation. A terrifically frustrated ego exists which drives eternally for expression, for a labeling or attachment of self by way of name to something—in medical and surgical parlance—some step in treatment or procedure in surgical technic, that the individual hopes may go down into posterity, thereby perhaps justifying one's having passed through this cosmos called world. This seems to be a part of the makeup of so many men in the field of medicine.

How else can one explain the making of an incision a half inch or so to this side or that side and calling it a "new method"; or reversing a suture line, starting at the top or vice versa at the bottom, or the accidental happening upon some procedure, which some less fortunate colleague used years before, and then rushing into

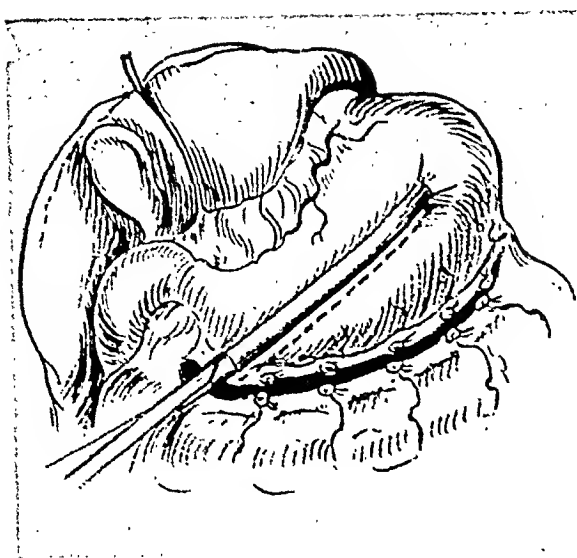


FIG. 22. Illustrating a step in the technic of the Jianu gastrostomy.

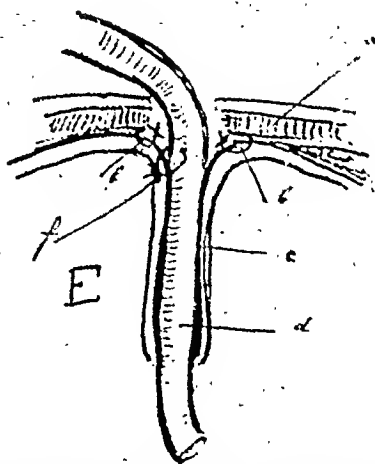


Fig. 23-III. — Schéma de la valvule. — E, cavité stomacale; n, paroi abdominale; A, suture séro-séreuse; c, valvule; d, sonde insérée dans la cavité séreuse de la valvule; f, point qui fixe la sonde à la séreuse.

FIG. 23. Illustrating the technic of one of the earliest French surgeons to use a tube.

print with a grand flourish, "a new method."

One sees this type of thing so much in a search or study of the medical literature of the past that one becomes stonily cynical and rather hard boiled in approach to anything labeled "a new." However, as a matter of historical accuracy it behooves some of us to scan with a degree of honesty, yet critically current contemporary claims to priority in these so-called "new methods" of doing this or that.

Medical achievement has been gradual and step by step. This is as it should be. One person here makes an observation and records it. Fortunate indeed that it should be this way. In another place some one tries it, and possibly finds it wanting and strives to improve upon it, adding a little something. Somebody else points out some deficiencies and tries to solve them. Thus by an evolution of ideas final perfection may be reached or approached. Medical historians in later years scan these contributions and give priority where it is due because there exists material evidence and corroboration in the printed word—in the original publications—in which the ideas were set forth for the use of the medical world at large.

This is particularly well illustrated in the historical evolution of the procedure of gastrostomy. We know and have proof,

documented proof, that a military surgeon named Egeberg, in statements before a medical society in Christiania made the following remarks: "I cannot see why the indications should not be just as great to open the intestinal canal to put nourishment in as to open it to take a foreign body out."

We surmise that Egeberg may have been influenced by reading of the experiences of another military surgeon, Wm. Beaumont with "old fistulous Alexis," illustrating to him that a man could live in health with a permanent opening in his stomach. We surmise this because we are aware that Dr. Beaumont's experience was much publicized in Europe and in addition because there exists a certain co-incidence as to dates and time.

From here on we find that process of evolutionary step by step improvement upon the original. A French surgeon, Sédillot in 1846, lifts a cone-shaped segment of the anterior wall of the stomach through an abdominal incision and behold you have the first completed operation of gastrostomy. But for reasons mentioned in the body of this article the patients died. Therefore, although the idea is a good one it must be made to work better.

Along in 1888, in 1890 and in 1893, three men, Girard, Von Hacker and Jaboulay proposed that instead of bringing the cone

of stomach wall directly to the skin through the abdominal wall, it should be brought through the subcutaneous tissues in such manner that the rectus abdominis muscle shall act in a sphincteric manner as to stop leakage around the attachment.

Although this was a minor improvement it did not solve the problem of spillage, skin excoriation, etcetra. So we find more names attached to contributions, one Sabanieff, one Hartmann, and a Frank, in the years from 1890 to 1893. These suggested various and sundry complicated passages of a *cone* or *anterior gastric wall* through and between the subcutaneous tissues and muscles. One suggested bringing the cone through the skin between the costal cartilages hoping to utilize the latter for sphincteric action. It is important to realize and emphasize that these men all were using a cone of tissue in view of what is coming later.

In 1894 and 1902, two men suggested twisting this cone of tissue so that when fastened to the abdominal wall, the torsion of the tissues would obstruct leakage and spillage. These men were Ullmann and Souligoux.²³

We return to France and *the French school of surgery for the first milestone in evolution of the operation, and give credit where credit is due*. In 1893, Pénieres proposed constructing a valve from gastric mucosa to combat leakage, and proceeded to perform the operation on dogs in his laboratory in Toulouse; whereupon another Frenchman, Fontan, not, however, without giving due credit to his countryman, proceeds to perform the operation on humans, differing in technic from his confrère in that he made his valve using all the layers of stomach wall instead of mucosa alone as did Pénieres.

The operation now consisted of a canal instead of a cone with a valve arrangement to prevent leakage. That was the operation as proposed by Fontan and Pénieres, a completed operation, the principles originated and laid down by them and the basis upon which any subsequent minor changes

were laid. *To these men should go the credit for the development of the procedure*. The operation to many was still one which could be improved upon.

Here again crops up that curious conduct on the part of the surgical mind. Where one man would propose placing a catheter through a stab wound into the stomach, then plicating the serosa over it by means of one or two purse-string sutures, one would rush into print with "a new method." The "new" consisted of placing first the stab wound a half inch or so higher or lower than the first proposer or instead of one or two layers of purse-string sutures advocating three or four, as providing greater strength to the finished canal, therefore, greater safety.

Then along came the men who courageously departed a bit farther and who may have been honest and upright in their thinking and advocacy of their ideas. These were the men who advocated the substitution of other hollow viscera as tubes between the stomach and skin. Such was the isolated pedicled loop of jejunum as advocated by Roux and Lexer and the isolated segment or pedicled loop of transverse colon advocated by Vuillet in 1911, and Kelling in the same year.

Somehow one gets an impression that Roux must have been in his seventh heaven playing with loops of intestines, attaching here and there, the more complicated, the more enthusiastic and delighted he was, much as a child with an erector set, but he used gut, instead of blocks or metal. It is a laborious piece of work to read of the different anastomoses he made and proposed.

Then along came the men who proposed the construction of tubed pedicled flaps from the stomach wall. Most prominent of these were Dépage and Janeway and both names were used connectedly to describe a technic and procedure *originated by Dépage in 1901*; but the story goes that Janeway was using and had originated a similar operation, entirely unaware of Dépage's work, so somewhere the idea got

abroad that he should be given credit with Dépage and the operation has since been spoken of as the Dépage-Janeway technic. It is curious that Dépage's article describing his procedure appeared in 1901, and Janeway's in 1913, a considerable discrepancy in time.

Here again that curious pattern of conduct: Dépage made his tubed flap with the base at the lesser curvature. Janeway made his with the base at the greater curvature, and insisted that his was the better method because it had a better blood supply, at any rate it was a "new method." Watsudjii combined Von Hacker's and Fontan's operations giving them credit while Spivack combined Fontan's and Dépage's operations and described it an "original"—"new method" without allocating proper credits.

Then came the tubed flap made by partial severance of the greater curvature of the stomach with the base at cardia and another with base at the fundus. These were: (1) the operation worked out in the laboratory by Alexis Carrell with Beck and called the Carrell-Beck procedure, and (2) the method of Jianu used successfully by Dr. George Pack.

It is quite possible that a more detailed and thorough perusal of available literature on the subject of gastrostomy might have brought to light even more material than is quoted here.^{29,30} However, over fifty different technics or plans of operation have been published by various authors and the predominant part of these had "A New Method" as part of their title.

However, in the past thirty-five years nothing new has been added to our technical knowledge concerning gastrostomy and no surgeon of recent times, or contemporary to the day is warranted lifting the work of the men who actually made the contribution and applying his own name to it. Sufficient documentary proof exists in published articles with names and dates to make any such conduct too easy to refute and make a lie.

CONCLUSIONS

1. A thorough survey of the available literature on gastrostomy has been made and the following conclusions have been reached:

2. Credit for conceiving the first gastrostomy, unreservedly belongs to Egeberg (1837). To Sédillot irrevocably belongs the credit for having performed the operation successfully (1846).

3. Credit for perfecting a watertight, continent and leak-proof valve from all layers of the stomach must be accorded to Fontan (1896).

4. For first developing a mucous lined tube from the entire thickness of the stomach, the credit belongs to Dépage, a Belgian surgeon (1901).

5. In order to perfect gastrostomy, the combination of two operations (Von Hacker's and Fontan's), was first done by Watsudjii in 1899.

6. A painstaking survey of the literature discloses that all other so-called "new methods" including Spivack's et al. are based on the work of the pioneers long passed.

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The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-fifth Year of Continuous Publication

VOL. LXXII

NOVEMBER, 1946

NUMBER FIVE

Editorial

HOSPITAL CONVALESCENCE MANAGEMENT

DURING the war years, a new medical service was created in the armed forces: reconditioning. Camouflaged under this name was a new departure in medical thinking, a scientific approach to the problems of convalescence management. In the centuries during which medicine has been practiced by specialized personnel, very little organized attention was given to convalescence. The average physician begins to lose interest as soon as the disease or injury he is treating is brought under control. For him, the intellectual problem has been solved.

Yet, second only to the greater challenge of prevention, is that of convalescence management in medicine today with its concomitant of maximum rehabilitation. Convalescence is the greatest portion in the longitudinal chronological section of most diseases and injuries. It is this feature which confers upon convalescence its social and economic significance. It is this feature which logically forced the armed forces into a consideration of convalescence on a scientific and practical basis.

Large scale warfare in the recent situation brought floods of casualties, concentrated in a short space of time, taxing

even the large physical and personnel resources of this relatively well medically developed nation. In order to meet the urgent military needs, attention was focussed upon the process of convalescence in order to shorten it, thus freeing hospital facilities for a more rapid turnover. Not a lesser consideration was the moral obligation of a nation to provide for the welfare of those citizens who had sacrificed themselves for the common good by restoring them to the best possible status, in the best possible manner.

The general structure and objectives of the reconditioning program have been described in detail elsewhere,^{1,2} as well as in many pamphlets and directives issued by the War and Navy Departments.³ For this presentation only the briefest of summaries will be made. Reconditioning in the armed services consisted of guidance in personal affairs and readjustments, orientation of the individual to an understanding of the basic reasons for the worth-whileness of his sacrifices, educational opportunities, planned recreation, physical training and occupational therapy.

As in all large scale endeavors with new concepts, the judgments formed varied with the bias of the observer as well as the

efficiency of the organization he observed. Those of us who were fortunate enough to see well run, efficient services could not fail to be impressed with successful accomplishment.

Let us contrast the course of a patient in a military hospital before and after establishment of efficient reconditioning services. In the first case, the patient is admitted, receives emergent treatment if indicated, and is sent to a ward. He is examined and treated by a medical officer from whom he receives less and less attention as his condition is controlled. Finally, he is allowed up "progressively," and ultimately discharged from the hospital. While convalescent he reads all the available magazines, visits the recreation hall, goes to an occasional moving picture, and interminably plays cards or "shoots crap." During the convalescent period, which may last weeks or months, he is terribly bored, discouraged; and if left with a residual disability, he is confused, perhaps visiting the chaplain or the Red Cross social worker for advice.

The difference afforded by a well functioning reconditioning service is marked. Unless he is acutely ill, immediately upon admission the patient receives a brochure which explains the hospital, the facilities and services it affords.⁴ Within the first few days, or as soon as his physician deems him able, he is interviewed by a trained counselor who questions him specifically concerning his personal problems, educational needs and interests. He is placed in the educational program by enrollment in one of its activities.

All activities are permitted only to the limit considered advisable by the physician in immediate charge of the case. However, each patient is classified by the physician as soon as he is able to participate, and instructors visit the wards for individual attention to bed patients. Ambulatory patients visit classrooms where they receive instruction from a wide variety of academic and prevocational subjects. In some hospitals, the range of

instructions has varied from higher mathematics to radio technology, from simple reading and writing for illiterates to job-printing.⁴

At the same time, while still a bed patient, the patient participates in periods of physical exercise for short periods during the day, which all receive in unison from trained physical instructors. The exercises are standardized and modified for various types of disabilities.³ Where possible, the element of competition is introduced by the use of simple games. As the patient becomes ambulatory, he graduates to more strenuous physical activities which are administered in the gymnasium and swimming pool or outdoors and which preferably include modified competitive sports.

Physical and occupational therapy are different modalities which approach the same ends as physical training. The separation of these fields in relation to patient care is more a consequence of their historical development than of logic. The patient receives both as requested by his physician. Therapists visit the wards to administer physical therapy treatments and to bring craft materials and prescribed activities for the individual patient. In the latter instance, craft work is chosen to suit the patients' needs for retraining of muscles and nerves in accordance with their interests, so that motivation is provided for sustained effort at the tasks.

Industrial therapy may be mentioned briefly as it was tried in the "Birmingham plan" at Birmingham General Hospital. By cooperation with one of the major aircraft producers, a branch shop of the company was set up in conjunction with the hospital. Selected convalescent patients, under careful supervision and specially trained foremen, actually worked on a limited scale in the production of aircraft parts, receiving regular wage scales for their labor. It had a great morale building effect as these handicapped men were able to

see a practical demonstration of their employability, indeed took home in cash the fruits of the demonstration. Though this approach has been an interesting one, it has remained in an experimental stage.

Recreation is provided systematically. Entertainment is obtained through the Red Cross and other local agencies, and shows are played both in the hospital auditorium and by smaller units in the wards themselves. Moving pictures also are brought to the wards, especially through the use of new automatic machines, which require little attention, and are moved as a unit with incorporated screen, needing only a slightly dimmed light. Patient participation in amateur entertainment is encouraged.

Finally, the guidance process started with the patient's admission is continued throughout his stay. Counselors check on his participation and answer his new questions. Testing services are offered, both for interests and abilities. Occupational counselling is an important part of the program. When the patient receives his final interview and is directed to the various civilian agencies that exist for his aid, a great deal has already been accomplished in speeding adjustments to illness or injury, and his social and mental adaptations to a handicap, if one will remain.

The use of such methods as those described in making the process of convalescence a more eventful one rests on a basis of physiological and psychological considerations which is continually expanding and becoming more sound. There has been a lag in the establishment of conclusive scientific evidence of the value of reconditioning activities because of the nature of the subject. The field developed under the stress of war, and it was not possible to conduct carefully controlled studies in the press of urgent needs. Further, the matter is different, for example, from the testing of a new drug. When sulfonamides or the new anti-

biotics appeared on the scene, it was a relatively simple matter for application of the scientific method. Animal experiments could be performed. Alternate cases could be treated by two methods, using subjects from a relatively homogeneous population. End points are clear. Organisms disappear, temperature descends. Conclusions can be drawn rapidly. However, in the evaluation of reconditioning methods, considerations are more complex. Too many other factors affect the length of convalescence. Objective criteria for such intangibles as personality adjustments are difficult to find and apply.

Nevertheless, certain things became evident to workers in the field. While results could not be measured in terms of days or personalities saved, some facts became obvious. An amputee who was subjected to intensive physical training and education in the use of his prosthesis was able to perform more tasks with it than an amputee who was simply given a prosthesis and a few perfunctory instructions for its use. Likewise, the amputee who received intensive guidance and exploration of his occupational possibilities was much better able to adapt to his new situation in a favorable manner than the patient who did not receive these advantages. Pneumonia patients who received definite graduated physical training in the hospital were returned to full duty faster and better able to carry on than those who simply sat around the wards for a few days after an arbitrary period of complete bed rest.

Recently there has been a growing interest in the physiological basis for reconditioning activities.⁵ In 1944, a whole series of articles appeared on the abuse of rest in various aspects of medical practise. Bed rest has been found by certain observers to have an effect upon vital metabolic processes, such as the utilization of carbohydrates.⁶ Circulatory stasis associated with bed rest has been incriminated as an etiological factor in thrombophlebitis and phlebothrombosis, with the subsequent

dangers of embolization. Calcium excretion increases and results in osteoporosis with increased incidence of urinary calculi during prolonged bed rest. Early ambulation following major operative procedures is becoming increasingly popular.⁷ Now clinical observations are being made breaking away from orthodox thinking about the significance of rest. Of interest is a recent article from an AAF hospital suggesting that complete bed rest may not favorably influence the course of rheumatic fever, if judgment is based upon the patient's subjective complaints rather than upon the usual criteria.⁸

Under the stimulus of the Baruch Committee on Physical Medicine, a new body of basic study is arising concerning the metabolism of resting subjects. For example, what is the effect of rest on tonus of the muscular and circulatory systems? There is no doubt that peripheral circulatory tonus is altered and becomes more unstable during prolonged bed rest. After a period of bed rest, which need not be overly prolonged, resumption of erect posture and limited activity is associated with asthenia, easy fatigability, sweats and flushes, near-syncope, which manifest unstable peripheral circulatory conditions. Effects on rest on cardiac output over long periods are less well known than the acute changes.

Application of reconditioning principles to voluntary hospitals has been suggested only recently. Lessons have been drawn from military experience in reconditioning⁹ as well as from more theoretical considerations.¹⁰ In the former instance, Gwynn recommends extensive administrative changes, with establishment of a reconditioning service on the same professional level as the surgical and medical services. He also recommends facilities based, like the administrative suggestions, upon his military experience. Such a program would be effective and complete and, in a large civilian hospital with suitable patient population, would certainly make an ex-

cellent basis for an effective program. However, it is suitable for operation only on a large scale, and a hospital of more than 1,000 beds would be required to permit economical operation of many features. Small hospitals cannot hope to afford space or money for gymnasium and swimming pool. In military hospitals, pre-vocational shops often included printing, radio, jewelry, woodwork, mechanic and welding shops, photographic laboratories, classrooms and business machines. For men in rural areas, gardens and scientific farming experiments were conducted. An approach of this type is not practical for small hospitals or for many large ones under present circumstances. Furthermore, the nature of the patient populations varies considerably in civilian hospitals from that found in military institutions. Special problems are introduced by the wide age spread from infancy to old age and by the varying ratio of acute cases.

Nevertheless, the need for a scientific and humanistic approach to convalescence management exists, and new methods must be devised for application of reconditioning methods to civilian medicine. It is only a relatively short time since the concept of preventive medicine became prominent, but the profession now recognizes its deep and important responsibilities in this regard. The physician has a moral responsibility to his patients, not only during acute illness but at all times. He is responsible before illness or injury for hygiene and prophylaxis. He is responsible likewise during the period of recovery for convalescence to be managed efficiently and to the patient's best advantage. When the patient lies in bed desperately fretting at his idleness, reading comic magazines or "true story" magazines, wondering at the comments passed by the staff on rounds in his presence, the responsibility of the profession for that patient's welfare is not being discharged. We all know that this situation occurs

all too often in the hospitals of the present time.

The reason for this situation is not obscure. New therapeutic measures permit much more effective definitive treatment of disease and injury. Attention has been focussed on penicillin, streptomycin, thoracic surgery and other dramatic measures. Specialization has proceeded to a point where the average physician too often sees the patient as one organ system with an appended soma and psyche.

The Baruch Committee on Physical Medicine has taken the lead in developing the ideas of reconditioning and rehabilitation for application to civilian situations. In a recent report,¹¹ the Subcommittee on Civilian Rehabilitation Centers, under the chairmanship of Dr. Howard A. Rusk, formerly Chief of the Army Air Forces convalescent rehabilitation program, defined the needs for rehabilitation activities on a community level, and presented a carefully thought out plan for the establishment of model centers. However, the concept should be extended from the emphasis on community rehabilitation of handicapped individuals to the application of scientific convalescence management principles to the voluntary hospitals.

It is possible for a hospital of 250 to 500 beds to introduce many of the more essential features of planned convalescence for its patients without incurring unreasonable costs in terms of space, personnel or money. Starting at the beginning, it would be a simple matter for hospitals to issue routinely to patients upon admission a small but attractive brochure describing the hospital routines and the opportunities and facilities afforded the patient. Guidance functions could be considerably improved by enlarging the paid social service staff, bringing the worker into closer contact with the patient. Workers should be assigned specific wards, and visit their wards at specified times, learning to know the patients'

problems and taking the initiative in supplying needed counsel.

In most hospitals, recreation is on a very rudimentary level. An auditorium is useful, and most hospitals have them, but much can be done right on the wards. Few hospitals at present make the maximum use of community agencies which can provide entertainment. Local entertainment employers as well as local unions have often proved very profitable sources for cooperation with military entertainment programs and should be explored for civilian voluntary hospitals as well. The new compact units previously described make possible a schedule of ward moving pictures with minimum effort. In hospitals for chronic diseases, more use could be made of excursions to points of interest for ambulatory patients.

Educational institutions in the vicinity of hospitals usually are willing and glad to arrange educational opportunities for patients at the hospitals. Often instructors are willing to give lectures or to conduct practical classes. Full utilization of community resources is rarely found at present. It could be achieved through existing agencies with small effort by better liason mechanisms.

On the basis of Army experience, two occupational therapists could account for a basic program in a hospital of 500 beds. Scheduled ward visits with carts equipped to carry tools and materials could afford facilities for many prescription cases as well as constructive diversion for many others. A small room for storage and preparation, and another for treatment of prescription cases would make possible the initiation of a program which in most hospitals would constitute a real advance.

Many hospitals are already equipped with public address systems channeled to each ward, and often to each bed. Often these are used merely for page systems, or to "pipe in" standard radio broadcasts. Yet these channels offer a wonderful opportunity for educational

programs and morale building activities. Besides the obvious music education, there are possibilities for language instruction, for talks on science, art, readings of poetry, talks on current events and other educational features which can serve to interest the patient in recovery and life.

One physical training instructor could care for approximately six to eight large wards daily, bringing the bed and ambulatory patients a planned and adapted program of exercise such as been previously suggested. A small room could be adapted for use in prescribed corrective exercises.

These suggestions are intended only as an indication of the possibilities for application of the new approach to convalescence. The chance for using individual initiative and ingenuity in developing inexpensive opportunities for the patient is endless.

These suggestions have been directed at the small hospital, but the concepts also bear application to the practise of medicine in the office and the home. The basic need is for the recognition by physicians that we are a long way from the discharge of our responsibilities when we lose interest at the moment the appendix comes out or the fever breaks. The physician must be concerned with the speed and efficiency with which his home-ridden patients are returned to useful social occupations. Hospitals can do nothing, even with the best of facilities, unless the physicians understand the reason for convalescence management and support its use. Basic research must be done, and new concepts and technic will emerge. The beginning must be made by education of the medical profession to one simple fact: *Your job isn't done until your patient's on the job.*

SUMMARY

1. A brief description is presented of the reconditioning activities developed in the armed forces.
2. Indication is made of the rationale for such program.
3. Possibilities are described for applying the principles of convalescence management to civilian hospitals.
4. The physician is described as having a permanent responsibility to his patients, before illness and injury for prevention, and after illness and injury for efficient convalescence and rehabilitation.

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EVALUATION OF COMMON PROCEDURES IN MAMMAPLASTY AND A NEW TECHNIC

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DURING and after the last World War there was a widespread popular curiosity concerning most of the sciences, particularly regarding subjects hitherto taboo or little known. The public interest, for example, in reconstructive surgery was heightened. The weakening of the Mrs. Grundy attitude of mind and the developments in reconstructive surgery, especially mammoplasty, were largely responsible for the present day increase in mammaplastic surgery.

An evaluation of the common technics seems necessary. These are: (1) Mammoplasty with free transplantation of nipple and areola; (2) two- and more-stage mammaplasties; (3) transposition ("buttonhole methods"); and (4) resection with transplantation of nipple and areola.

MAMMAPLASTY WITH FREE TRANSPLANTATION OF NIPPLE AND AREOLA

This technic was first described¹ in 1921 and published² in 1922 by Thorek. Dartigues³ in Europe advocated the Thorek method. Axhausen⁴ compared mammaplasty with free transplantation of nipple and areola to Lotsch's⁵ technic (published in 1923). Weighing the advantages and disadvantages of the Lotsch transposition method and its possible complications (necrosis of nipple and areola) Axhausen discussed the Thorek technic, but was doubtful of the "take" of the freely transplanted nipple. Maliniac⁶ challenged the possibility of "take" in a freely

transplanted nipple. "The 'take' of a freely transplanted nipple," he wrote, "is technically impossible, as the ducts and muscle fibres will unavoidably slough." He came to the further conclusion that: "Mammectomy, as a plastic method for benign hypertrophy, is a crippling procedure injurious to the physical and mental health of the patient."

Thorek,⁷ in rebuttal to this contention, furnished "indisputable histologic proof of successful taking of transplanted nipples, and the histologic presence of muscular, ductal, nervous, glandular and other normal components of the nipple." Thorek's re-emphasis of mammaplasty with free transplantation of nipple and areola popularized the technic.

Today certain indications for mammaplasty are widely accepted but two important factors have been given little consideration, for example, (1) A statistic survey of women operated upon for hypertrophy of breasts showed a ratio of 300 women at the age of sexual maturity to 2 women who underwent the operation after menopause. (2) During the last few years there has been a change in the age incidence of women undergoing reconstructive surgery of breasts. Prior to World War II the average age of women desirous of having a mammaplasty performed, ranged from the thirtieth to the fortieth year. A woman "disfigured" by childbirth and nursing usually postponed the operation until the children were no longer infants. At the present time the average age of



FIG. 1. Milk secretion from both nipples three weeks after mammoplasty (slanting technic).

prospective patients ranges between the twentieth and thirtieth year.

This incidence is explainable on the following basis: Women whose husbands were serving overseas decided (without consent of the husband) to undergo the operation. Women acquired independent incomes through work in war plants. They wanted to appear to the best advantage to the returning husband. The question of possible pregnancy rendering a mammoplasty inadvisable no longer required an answer. Reports of "miraculous achievements" in plastic surgery reached circles hitherto unfamiliar with the specialty. The competition of "sweater girls" and "pin-up girls" opened a frank discussion of breast contours. The pictures of South Sea Island beauties with conic breasts challenged the figure consciousness of "the girls left behind." Magazine articles on sex hormones still furthered figure consciousness.

Infant nursing, as is manifest to every one, is becoming more and more a lost art. Today some pediatricians favor the "milk formula" and often discourage healthy women from even attempting to nurse their baby. Esthetic considerations often enter here. The growing knowledge of the "milk factor" in development of neoplasms may perhaps justify the attitude of the pediatrician. It is also known that the milk producing function of hypertrophic breasts is almost nil.

The subconscious maternal instinct, of course, is unchangeable. One of the main questions asked by young women contem-

plating plastic repair of hypertrophic breasts, is invariably repeated as follows: "Can I nurse a baby after a 'breast plastic'?" And then hesitatingly: "If I want to, or if my doctor will let me."

The physiologic function of the breast (production of milk and its passage through the mammary ducts) is rendered impossible by all procedures which disconnect the mammary ducts within the nipple from the excretory ducts of the underlying acini. Even though "indisputable proof" has been furnished of the presence of muscular, ductal, nervous, glandular and other normal components of the nipple, the milk ducts leaving the acini (if any remain) cannot be reconnected with the ducts of the freely transplanted nipple. *No surgical procedure can accomplish this reunion.*

From the theoretic viewpoint, each mammary duct within the freely transplanted nipple can be kept open by insertion of fine tantalum wires. By connection with the corresponding excretory ducts of the underlying acini, the restoration of physiologic function is *imaginable* but technically impossible. Practically, however, the ducts of the acini can hardly be delimited during surgical procedures. Furthermore, from the theoretic viewpoint, the search for excretory ducts of the acini would take even the experienced surgeon many hours. The direction of the residual breast tissue after resection differs, moreover, from its original position, depending on the resection procedure used.

Thorek's term "mammoplasty with free



FIG. 2. Same patient as in Figure 1; lateral view.

transplantation of the nipple" and Maliniac's "mamnectomy with free transplantation of the nipple" have dissimilar meaning from the surgical viewpoint. In his first publication in 1922, Thorek² described "mamnectomy" and not "mammaplasty." In his publication in 1945⁷ Thorek revised his technic, to wit: ". . . after resection of the breast substance to the desired extent. . ." This implied "mammaplasty" with preservation of some breast tissue. He concluded: "The ideal results one aims to accomplish in plastic reconstruction of the breasts . . . they must be able to function (endocrinologically). Enough tissue is left behind in a properly performed reconstruction operation to assure endocrine function." The statement that "the newly reformed breasts must be able to function (endocrinologically)" must be evaluated as to its validity.

What is the endocrinologic function of the breast? The female breasts are con-



FIG. 3. Complete necrosis of left nipple and incomplete necrosis of the left areola after transposition with resection of subcutaneous fat and lower pole of parenchyma. During subsequent pregnancy galactoceles developed.

sidered skin glands containing fatty, connective and alveolar tissue. The mammary ducts, terminating in the nipple, are the ultimate exits of the excretory ducts of the acini. In the beginning of the menstrual cycle connective tissue responds to the stimulus of estrogens, while later proliferation of acini takes place through hormonal influence of the corpus luteum. Both tissues furthermore respond indirectly to hormonal stimuli of the hypophyseal and adrenal cortex glands.

The hormonal influence of the thyroid gland on the breast has been proved by administration of thyroid preoperatively solely for deficient milk secretion. (It is commonly known that the thyroid gland often becomes enlarged during pregnancy and returns to normal size after childbirth.) The breast, during pregnancy, similarly affects the adrenal gland as is shown by the increase of pigmentation within the areola.

From the aforementioned facts it can logically be deduced that the breast during pregnancy, either directly or indirectly, exerts a hormonal stimulus on other endocrine glands.

A theory has been propounded to the effect that breast tissue proper is an endocrine gland, producing a hormone which re-



FIG. 4. Unsatisfactory cosmetic result after two-stage mammaplasty. (First stage: transposition of nipple and areola with resection of subcutaneous fatty tissue; second stage: resection of parenchyma and excess skin in submammary folds.)



FIG. 5. Same patient after transplantation of nipple and areola with resection of parenchyma (slanting technique).

influences the hormonal cycle. All scientific reports in support of this theory are based on experimental work carried out on animals.

Geschickter⁸ refers to the endocrine function of the breast as a one-sided response (connective and alveolar tissue) to the influence of ovarian, corpus luteum, and indirectly, hypophyseal and adrenocortical stimuli.

The following case history appears to add biologic and physiologic significance to the endocrine character of the breast:

A. H., thirty-two years of age, a white housewife, who had a normal childbirth ten years previously, suffered from hypertrophic pendulous breasts. She attributed alienation of husband's affection to this deformity. Mammaplasty was performed with the slanting technic. Metrorrhagia occurred immediately following return from the operating room. Menstruation lasted five days. The post-surgical period was uneventful. Three weeks after mammaplasty, milk secreted from both nipples. The subsequent menstrual period occurred four weeks after mammaplasty. Milk secretion ceased with the appearance of menstru-

ation. (I have frequently observed that metrorrhagia occurs subsequent to mammaplasty. This can be considered as evidence of the endocrine nature of the breast itself. Admittedly, metrorrhagias frequently occur following any surgical intervention.)

A great number of patients suffer from metrorrhagia following mammaplasty. Surgical intervention apparently stimulates breast tissue to act as an endocrine gland. This stimulation primarily involves the menstrual cycle. In the particular instance previously mentioned surgical intervention furthermore stimulated the hypophyseal gland and its galactogenic hormone.

Surgical intervention, therefore, can be considered a hormonal stimulus similar to that of pregnancy. *The stimulated breast tissue acts as an endocrine gland.* This fact is of transcendent importance in regard to mammaplasty. The question may well be asked: How will the remaining mammary tissue function (endocrinologically) in examples of mammaplasty with free transplantation of nipple and areola? (In "mamnectomy" resulting in breast-like formations of fatty and skin tissue, the hormonal stimuli will not find responsive tissue.)

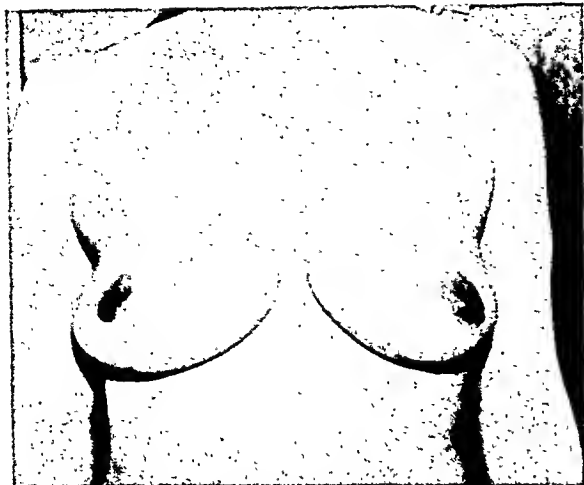


FIG. 6. Transposition of nipple and areola with resection of subcutaneous fatty tissue. (Note distortion of nipple and areola by traction of unsuspended parenchyma.)



FIG. 7. "Pancake-breast" resulting from transposition of nipple and areola with resection of parenchyma. Note extensive scars in submammary folds.

Residual breast tissue responds to hormonal stimuli. These stimuli, once established during adolescence, continue during sex maturity. It is commonly known that many women before menstruation complain of drawing sensations, swelling of the breasts and sometimes even a slight discharge from the nipples.

When pregnancy occurs hormonal stimulus is increased. The breast connective tissue proliferates, the acini enlarge in size and increase in number, and under the additional influence of galactogenic hormones, milk is produced and finally excreted through the mammary ducts.

I have never observed breast changes during pregnancy after mammoplasty with free transplantation of the nipples. But it is germane to report on two patients, seen in consultation, in whom pregnancy occurred after mammoplasty with subsequent necrosis of nipples.

CASE REPORTS

CASE I. P. G., a twenty-two year old white, plump woman, married, had followed a rigorous diet of black coffee and cigarettes because her husband insisted that she become "streamlined." He was soon proud of her new silhouette, but disliked contours of her breasts which were disproportionate to her newly acquired contours. Mammoplasty was performed according to the modified Lexer-Kraske technic. Possibly due to secondary anemia, post-surgical compli-

cations—necrosis of both nipples and areolas—developed. After this marriage ended in divorce, the patient married again. The second husband insisted she become pregnant. Complications started during the third month of pregnancy. The patient complained of drawing pains in both breasts. Milk abscesses developed at the end of the fourth month. Surgical intervention was urgent. Additional milk abscesses developed and were treated surgically. At various periods artificial termination of pregnancy was contemplated, but the husband objected. Milk abscesses became more numerous and further surgery was found exigent. At the end of the eighth month albumin was found in the urine in increasing amount, and finally a cesarean operation was performed with blood transfusions.

CASE II. L. F., a thirty-two year old white woman lawyer, suffered from enormous hypertrophy of both breasts. She was engaged for seven years but refused marriage because she was conscious of her deformity. Mammoplasty was performed (Lotsch transposition with resection of subcutaneous fat and lower pole of parenchyma). Primary healing of the right breast took place and there was a satisfactory cosmetic result. The left breast developed bluish discoloration with subsequent necrosis of nipple and areola. Several months later a secondary correction of the left nipple was performed by forming an artificial protuberance with subsequent tattooing. The patient married soon thereafter and became pregnant. At the beginning of the third month she complained of a drawing sensation in the left breast. In the fourth month a cyst-like formation ap-

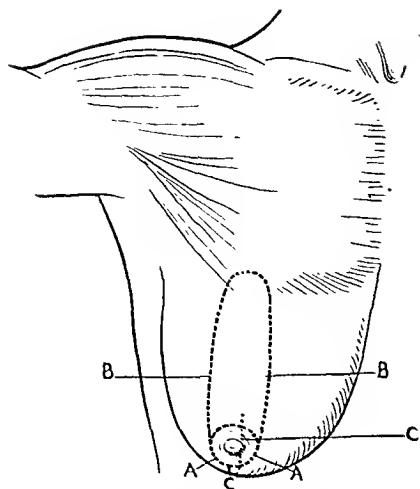


FIG. 8. A, skin incision around areola; B, arc-like skin incision to site of new placement of areola; C, vertical skin incision from middle areolar area to lowest margin of breast.

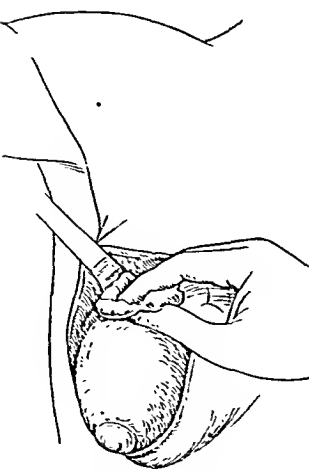


FIG. 9. Undermining of entire skin covering breast.

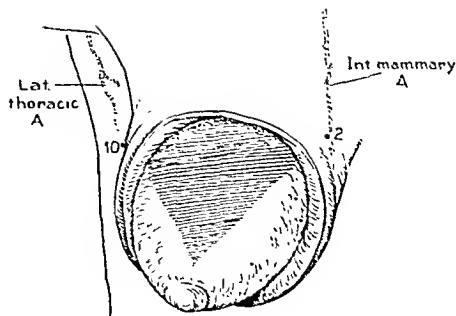


FIG. 10. Removal of wedge-shaped segment of breast tissue in upper quadrant of breast.

peared in the lower outer quadrant of the same breast. No chills, temperature or redness of skin occurred. Aspiration showed milky, butter-like contents. Diagnosis: galactocele.

Consultation was carried on with several specialists who concluded that roentgen-ray treatment was preferable to surgery. Six treatments were given following aspiration. Two weeks after the last roentgen-ray treatment the axillary glands became enlarged and sensitive. Lymphedema developed in the left arm without response to treatments. A spontaneous miscarriage occurred at the end of six months. There was a discharge from the right nipple for about six weeks with a drawing sensation in the left breast; the enlarged lymph glands in the left axilla and lymphedema of the left arm subsided in two weeks. The patient refused a second pregnancy, but developed a serious psychotic condition which was successfully overcome by adoption of a baby.

It may reasonably be argued that the histologic and pathologic pattern of breast tissue differs in examples of necrosis of nipple and areola from that of freely transplanted nipple and areola. Necrosis of the nipple nearly always involves destruction of underlying ducts, acini and connective tissue. Scar tissue often includes excretory ducts. Chronic mastitis in the adjacent area is not infrequent.

In the physiologic sense the condition present after mammoplasty with free transplantation of nipple and mammoplasty followed by necrosis of the nipple is the same. There is no outlet for the galactophorous ducts. The danger of hormonal stimulation as such and the increased stimulus during pregnancy and lactation is similar to that described in the previously mentioned case histories.

Mammoplasty with free transplantation of nipple and areola, performed on any woman during sex maturity, as advocated by Thorek and others, in my opinion, is dangerous and in contravention of modern concepts of hormonal physiology.

If hysterectomy with oophorectomy has deprived a woman of her gestatory function, or if mammoplasty is desired after menopause, the operation with free transplantation of the nipple may be considered. If during hysterectomy part of the ovaries remains, the residual breast tissue after mammoplasty with free transplantation of the nipple is still susceptible to hormonal stimuli.

Mammoplasty with free transplantation of nipples is definitely contraindicated for all women whose sexual maturity is not ended.

The differentiation between true hypertrophy (during the onset of adolescence or

ADDITIONAL PARENCHYMA REMOVED BY SLANTING TECHNIQUE

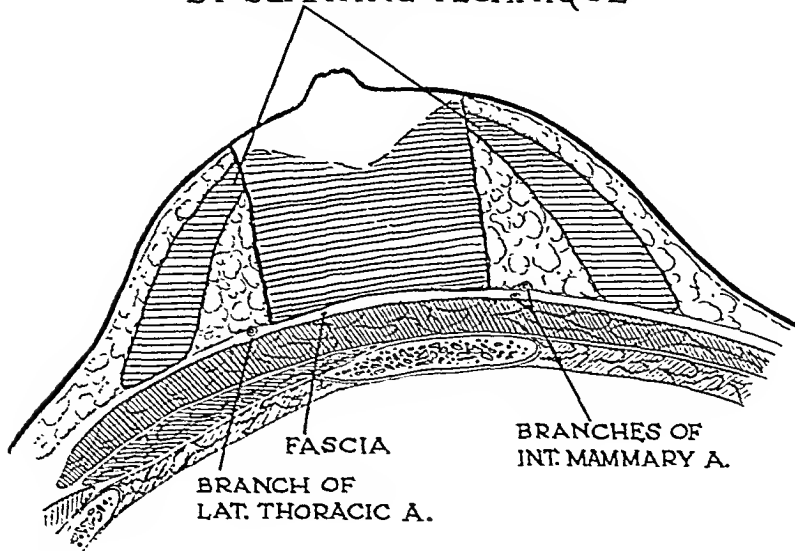


FIG. 11. Author's slanting technic for hypertrophic pendulous breasts.

early pregnancy) and excessive adiposity of the breast is important from the viewpoint of causative factors. But the surgical approach has no relation to the diagnostic differentiation. The surgical aim must be elimination of physical and mental suffering. "Mammectomy," comprising the resection of all breast tissue and formation of a breast-like appearance (consisting of fatty and skin tissue) is the simplest surgical technic. But "mammaplasty," with preservation of the smallest amount of tissue, able to respond to hormonal stimuli, is unsuitable for the aforementioned reasons.

Another important consideration is the danger of tissue damage induced by the response of residual breast tissue to hormonal stimuli after mammaplasty with free transplantation of nipple and areola. It must ever be borne in mind that *tissue damage is considered today as an important factor in the development of neoplasms.*

TWO- AND MORE-STAGE MAMMAPLASTIES

The grave complication of necrosis of nipple and areola in mammaplastic procedures was realized early in the history of reparative surgery. After Kraske⁹ described his basic method of breast reconstruction with resection of breast tissue and trans-

plantation of nipple and areola, many surgical complications were reported. Various suggestions were offered to eliminate the possibility of such complications.

In 1929, Schreiber¹⁰ described a two-stage surgical procedure. In the first stage, resection of breast tissue with transplantation of attached nipple and areola, was carried out in the upper half of the mammae; in the second stage, after an interval of at least four weeks, glandular tissue was resected in the lower half of the breast and skin was adjusted to the new contours.

The two-stage operation was adapted by a number of surgeons because: (1) It preserved the blood supply by resection, in one stage, of a relatively small amount of breast tissue; (2) it preserved the subcutaneous arterial plexus which supplies nipple and areola; (3) it prevented shock following prolonged operating time and consequent prolonged tissue exposure, and (4) it prevented tissue necrosis by concentration of arterial blood supply in a limited area.

The same considerations were kept in view in another two-stage approach; the correction of one hypertrophic pendulous breast at a time, and a repetition of the procedure on the other breast after an interval of at least four weeks.

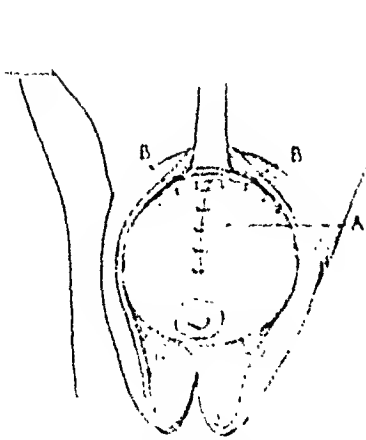


FIG. 12. A, interrupted sutures through entire breast tissue, following removal of wedge-shaped section; B, interrupted, suspension sutures connecting newly shaped breast to fascia of pectoralis major.

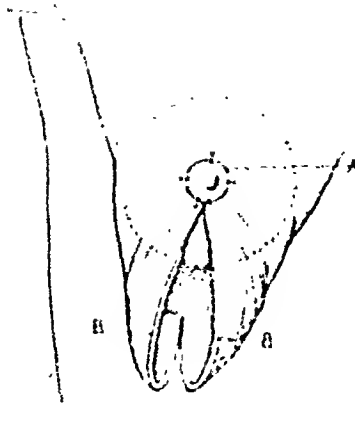


FIG. 13. A, skin replaced in original position and areola united by temporary, interrupted silk sutures; B, redundant skin in lower part of breast.

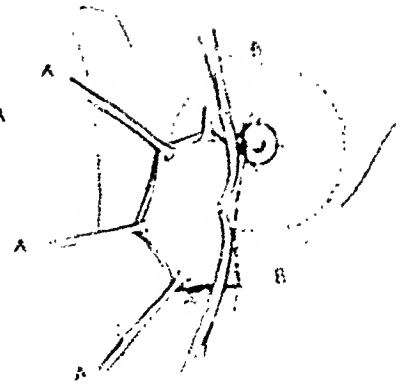


FIG. 14. A, redundant skin on both sides of original vertical incisional line, drawn forward above the reconstructed breast; B, curved Kelly forceps transfix redundant skin flaps.

The following case histories are perhaps of interest:

CASE REPORTS

CASE I. A. M., a twenty-five year old white woman, unmarried, whose previous history is irrelevant, enlisted in the WACS. She was always conscious of overdeveloped breasts and became more so in regard to the disproportion in a tight-fitting uniform. The surgeon suggested reconstruction of the right breast, to be followed four weeks later by that of left breast. Mammoplasty of the right breast was performed. The post-surgical period was uneventful. The result was satisfactory from a surgical and cosmetic viewpoint. The patient requested a second operation in a month but was then informed that physician was ill and could not perform a second operation before at least six months. She resumed her military duties ever conscious of artificial asymmetry of her breasts, which she could conceal only by placing cotton pads over the reduced breast and squeezing the unoperated breast into a tightly fitting brassiere. She received orders for overseas duty before the surgeon resumed his practice. She remained overseas for two years, acutely conscious of her deformity which she could not conceal from her associates under primitive camp conditions. The patient developed a psychoneurosis which she tried to overcome by meritorious war work. When she returned from war, she consulted another surgeon. Despite

the successful outcome of the first operation, her inferiority complex and emotional reaction destroyed her confidence in the surgeon who performed the first operation.

CASE II. J. D., a twenty-eight year old white woman, who was a professional model, wore tight brassieres with resultant prolapse of both breasts. When strapless bathing suits and evening gowns became fashionable her professional earning capacity was reduced because of her pendulous breast condition. On consultation with a surgeon she was advised regarding the safety of a two-stage operation. The first operation was successful from a surgical viewpoint. (Incomplete resection of parenchyma in both upper breasts with transplantation of nipple and areola.) The patient was eager to return for a second operation. Unfortunately, her mother became ill and her earnings were spent in payment of hospital bills. Finally, she lost her job and was unable to hide her massive breasts even with clever contraptions. Economic circumstances worsened and the patient could not undergo a second operation. Five years passed until the patient saved enough money to pay the necessary expenses of a second operation.

Joseph¹¹ introduced an additional procedure—a three-stage mammoplasty—in order to prevent interference with the blood supply of the nipple and areola. In the first operation he resected a small

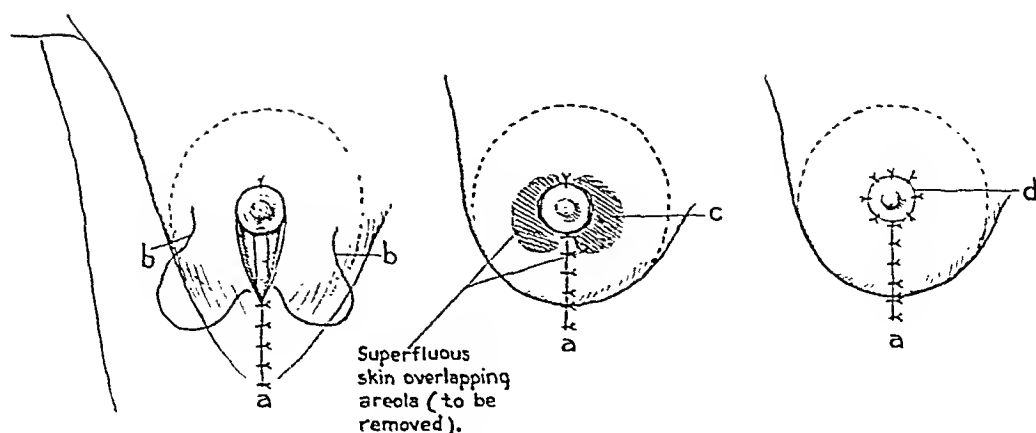


FIG. 15.

FIG. 16.

FIG. 17.

FIGS. 15, 16 and 17. A, skin suture beginning at lowermost part of initial vertical incision; B, mattress suture, connecting uppermost point of vertical skin suture with lowest part of areola; C, redundant skin overlapping areola, following the insertion of mattress suture; excess skin is subsequently removed. D, final skin suture circumscribing areola.

amount of skin, subcutaneous and breast tissue above and below the nipple of one breast; in the second operation the same procedure was carried out in the other breast; in the third stage, about two months later, the excess tissue of the lower breasts was resected and the skin adjusted in the sub-mammary fold. (Maliniac¹² repeatedly emphasized the prevention of complications by a two-stage mammoplasty.)

The contraindications to two- or more-stage mammoplastic procedures are: (1) psychologic, (2) economic, and (3) esthetic, at times.

It is obvious that a healthy person dislikes to undergo a surgical operation. A woman suffering from hypertrophic pendulous breasts, however, will submit to one operation in order to have the deformity corrected. But the suggestion of a two-stage operation is discouraging and depressing. If she finally accepts the surgeon's advice concerning a two-stage mammoplasty, her psychosomatic condition may impair the primary healing. The possible shock produced by a second anesthesia within a short period makes her relatively unsafe for surgery.

The economic aspect of a two-stage mammoplasty is of equal importance. When only women of leisure and wealth underwent mammoplastic corrections,

neither time nor money interfered with the surgeon's plans. Today, the average woman desiring mammoplastic reconstruction comes from a different stratum of society. She is usually employed. She is permitted a limited absence, and the mammoplasty must be completed within a limited period on limited finances. A second hospital expense often renders the desired "breast plastic" impossible. A second leave of absence may result in the loss of her job.

The esthetic advantages of a two-stage operation are questionable. The surgeon who specializes in mamma reconstruction, must not only be experienced in that field, but truly an artist as well. During and after the operation tissue changes take place which may vary in different areas and in different persons. A retromammary or lateral hematoma may form with congestion. The breast or breasts after the first stage seldom regain their final contours even after four weeks. This in itself may reveal asymmetry.

Where the term "two-stage mammoplasty" implies incomplete resection of both breasts in the first operation, the two breasts may present an asymmetric adjustment at the time of the second operation. The final result will be esthetically unsatisfactory.

In all examples of true hypertrophy or hypertrophic pendulous breasts of enor-

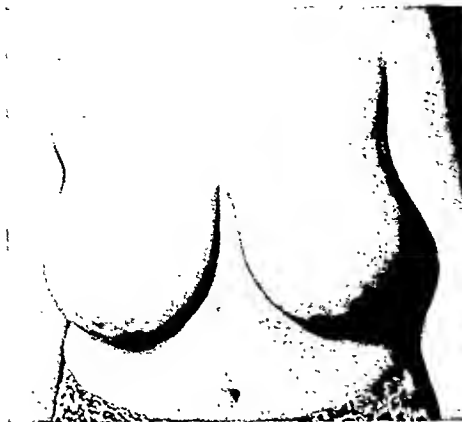


FIG. 18. Virginal hypertrophy (fourteen-year old patient).



FIG. 19. Same patient as in Figure 18 after mammoplasty (slanting technic).

mous volume a two- or more-stage operation should be seriously considered as the procedure of choice. But where a medium degree of prolapse is present (the umbilical level may be considered as a dividing line) a one-stage operation can be performed successfully if hemostasis is thorough and infection avoided, and proper time-saving surgical procedures are utilized.

TRANSPPOSITION OF NIPPLE AND AREOLA ("BUTTONHOLE" METHODS)

In 1923, Lotsch⁵ described a technic of transposition of nipple and areola in which they remained connected with the underlying breast tissue and were transposed to the recipient area. After a vertical incision from the lowest point of the transposed areola into the submammary fold, additional skin wedges were resected on both sides of the vertical incision. Nipple and areola were therefore transposed into the desired location and prolapse of the skin was eliminated. No suspension of the breast itself was carried out. The entire support was based solely on the skin.

In the slightest degree of prolapse the parenchyma situated below the nipple is more voluminous than above the nipple. Without suspension a new ptosis is brought about in a short time.

In 1928, Lotsch¹³ described a second transposition technic with simultaneous resection of subcutaneous fatty tissue along the entire surface of the mammary

gland. The parenchyma remained undisturbed. The removal of excess skin was effected, not only in the aforesaid manner, but by additional resection in the submammary fold.

In examples of extreme hypertrophy, Lotsch also resected parenchyma by a horizontal excision in the lower pole of the breast.

It is evident that transposition of nipple and areola without resection of subcutaneous fatty tissue or breast tissue itself is only effective in atrophic pendulous breasts in which no reduction of volume is required.

Transposition of areola and nipple with simultaneous resection of subcutaneous fatty tissue or breast tissue is adequate where there is great hypertrophy.

From the cosmetic aspect the results of transposition methods without resection of fatty or breast tissue are unsatisfactory. The elasticity of the skin being reduced prior to reconstruction is inferior to the normal tonicity of breast skin. Even by slight increase in parenchymal volume ptosis recurs. The result is never permanent.

When the breast in its entirety is reduced in volume, the skin incision in the submammary fold extends medially to the sternum and laterally at least to the level of the transposed areola. The result is the so-called "pancake breast," with scars visible medially in a low-cut gown and laterally in a bathing suit or "halter." As the horizontal incision does not reunite the

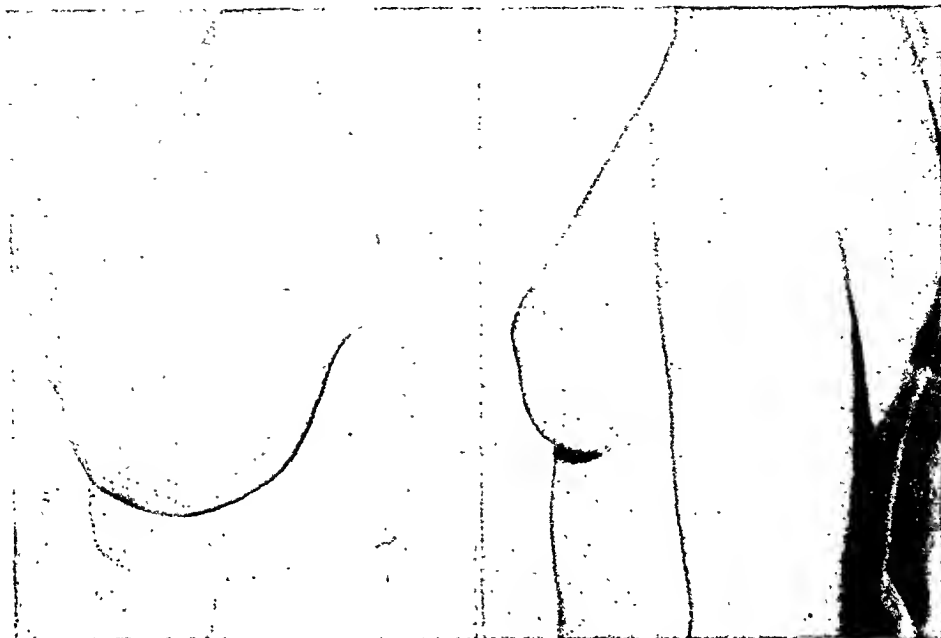


FIG. 20. Hypertrophic pendulous breasts.

FIG. 21. Same patient as in Figure 20 after mammoplasty (slanting technic).

"Langer skin tension lines," it cannot fade into a mere hairline.

When ptosis of the breast recurs, after transposition with resection, the horizontal incision apparently moves upward and becomes wider by being actually drawn apart.

The parenchyma amassed below the nipple, without suspension will "pull" on the transposed nipple and areola and distort their direction. This distortion is apt to cause subsequent sloughing and necrosis of transposed nipple and areola.

RESECTION WITH TRANSPLANTATION OF NIPPLE AND AREOLA

The Lexer-Kraske⁹ method is considered the basic procedure in modern mammoplasties. It consists of resection of breast tissue, including fatty, connective and glandular elements; formation of a normally sized breast proportional to the general configuration of the patient; suspension of the newly-formed breast on the fascia of the pectoralis major; transplantation of nipple and areola in the desired location; resection of excess, and adjustment of residual skin to the newly-formed breast.

In all methods of resection of breast tissue with transplantation of nipple and areola the most important consideration is:

Which part of the breast tissue should be resected?

In the original Lexer-Kraske method a section of the lower medial parenchyma was resected.

Biesenberger¹⁴ resected the outer half of the mammary parenchyma including contiguous fatty tissue by an S-shaped excision, beginning in the axilla and extending to the lower pole of the mammary gland below the nipple and areola. The advantage of the S-shaped excision apparently lies in the preservation of blood supply in the immediate vicinity of areola and nipple. A second advantage is the resection of an equal amount of breast tissue above and below the nipple.

The S-resection preserves the internal mammary artery, while in even slight degrees of hypertrophy the lateral thoracic artery is injured or severed. The perforating branches of the intercostal arteries supplying nipple and areola remain intact.

After reduction of the breast parenchyma and suspension of the newly-formed breast on the fascia of the great pectoral muscle excess skin is removed not only by wedge excision lateral to the vertical incision but by an additional horizontal excision within or below the submammary fold.



FIG. 22. Asymmetric hypertrophic breasts.

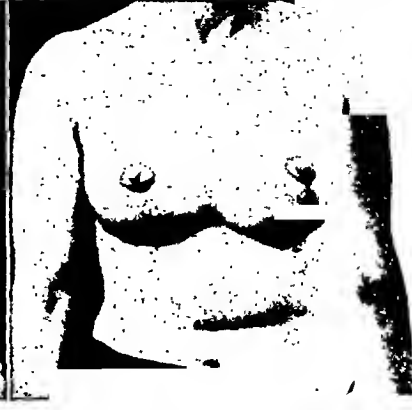


FIG. 23. Same patient as in Figure 22 after mammaplasty (slanting technic).

The danger of the Biesenberger modification, especially so in heavy, pendulous breasts, is the elimination of important arterial blood supply and the direction of the approximation of remaining breast tissue. This approximation is accomplished by raising the lower lateral to the upper medial wall of the residual parenchyma. The union is approximately above the internal mammary artery.

Obstruction of the lateral thoracic and congestion of the internal mammary arteries may impair the blood supply in this area. The entire parenchyma is distorted, and the excretory ducts of the acini are diverted from their normal directions. Nipple and areola, too, connected with the residual breast, are deranged in order to fit the newly-formed breast.

A second disadvantage of the Biesenberger modification (as in the original Lexer-Kraske method) is the removal of excess skin within or below the submammary folds. The skin incision, similar to the Lotsch transposition method with resection of tissue, reaches medially to the sternum and laterally either to the border area of the serratus anterior muscle at the level of the areola or, if carried out in straight horizontal direction, to the lower lateral aspect of the thorax. This extended scar is not in conformity with modern esthetic requirements.

From the surgical viewpoint, the obstruction of the lateral thoracic artery, the

distortion of breast parenchyma and derangement of nipple and areola may induce congestion, resulting in sloughing and necrosis of parenchyma and of the areola and nipple.

Many other modifications of resection with transplantation of areola and nipple have been advocated.

AUTHOR'S TECHNIC

The two basic aims in mammaplasty are: (1) surgical safety and (2) satisfactory cosmetic result. Apart from a surgeon's possible inexperience and inefficiency failures in mammaplasty are due in most instances to complications arising during or after the operation.¹⁵

Manifestly that part of the parenchyma should be resected which is subjected to the greatest degree of damage. *This is the breast tissue situated in the upper medial quadrant above the nipple.* The connective tissue within this area loses its elasticity due to the steady "drag" of the hypertrophic parenchyma. The alveolar tissue degenerates owing to the same cause. The excretory ducts are elongated and collapsed. The arteries are stretched. The vein valves are defective. Superficial venous anastomoses appear as heavy cords within the atonic skin. Striae are further evidences of the "breakdown" of subcutaneous elastic tissue. The lymphatics are congested. The area in question, weak in its various components, is unsuitable for the formation of



FIG. 24. Lateral view.



FIG. 25. Same patient as in Figure 24 after mammoplasty (slanting technic).

a "new" breast, and even more so as a base for suspension. The damaged tissue carries in itself potentialities of development of neoplasms. For the aforesaid reasons parenchyma must be resected in the *upper medial area*.

The internal mammary artery usually enters the posterior aspect of the mamma in the two and two-thirty (clockwise) area. The lateral thoracic artery enters between ten and ten-thirty. Resection of parenchyma between these "figures" does not interfere with the main blood supply. It will definitely eliminate the "weakest" tissue.

In hypertrophic breasts the skin incision encircling areola and nipple is restricted to the epidermis. A parallel incision is carried out one and one-half inches distant from the first and extended to the anterior ligament of Cooper. The undermining of skin is effected by blunt gauze dissection. Undue injury to the tissue is avoided and surgical bleeding is eliminated.

Large arteries, of course, must be carefully clamped before surgical severance. Thorough hemostasis is an absolute requirement. When oozing cannot be controlled by suture ligatures, local use of coagulants is advisable. Vitamin K is indicated in excessive bleeding during operation.

Where extreme hypertrophy is not adequately reduced by resection of breast

tissue between ten and two (clockwise), the resection must be extended medially and laterally, depending on the excess volume of parenchyma. This additional resection should be effected in a *slanting* direction, starting at both walls of the separated parenchyma and passing downward to the extreme border of the area to be excised. By this "slanting technic" only the terminal branches of the internal mammary and lateral thoracic arteries can be severed, while the main arterial trunks remain intact.

The union of residual parenchyma must be firm. Internal and external rows of catgut sutures insure complete closure. At the same time the desired fullness of parenchyma above the nipple is obtained by a wider margin of the posterior and a narrow approximation of the anterior areas.

Immediately on suturing areola and nipple into the previously excised skin arc, they are covered with alcohol-saturated gauze. When nipple and areola appear "pallid" or "bluish" during the operation, repeated alcohol applications produce hyperemia and thereby restore normal color.

The removal of excess skin is carried out on both sides of the vertical incision. The symmetric adjustment of the skin covering

the newly-formed breast is established before resection of the skin flaps.

Subcuticular and intracuticular catgut sutures are used for the approximation of skin borders. Final skin suturing is begun at the lowest point of vertical incision and continued upward (silk sutures).

After the vertical skin suturing is extended in length one-quarter of an inch less than the distance between the upper margin of the breast and the highest point of the transplanted areola, a mattress suture is placed between the last vertical suture and the lowest point of the areola.

Skin, now overlapping the medial, lateral and lower borders of the areola, is resected circularly. The circumference must be of equal distance or slightly less than that of the transplanted areola, because undue stretching of areola and nipple may impair the blood supply. Removal of excess skin within or below the submammary fold is consequently superfluous.

By resection of parenchyma in the upper and vertical removal of excess skin in the lower part of the breast, the inner and outer surgical fields do not overlap.

Primary healing of both fields is secured by separate blood supply.

The cosmetic appearance following this technic is superior to all procedures resulting in extensive submammary scars.

The patient must furthermore receive the benefits of the latest medical advances, for example, correct premedication is essential. Forty thousand units of penicillin are administered intramuscularly three hours prior to operation. Ten thousand units are given every three hours for three days following operation. (Penicillin not only prevents post-surgical infections but reduces the so-called normal post-surgical absorption temperature.) The choice of the proper anesthetic and of an expert anesthetist are of the highest importance. The emotional status of the patient, her habits (cigarettes, liquor, sedatives, stimulants) must be taken into consideration. An experienced assistant is of paramount

importance for a speedy surgical operation. In all examples of mammary hypertrophy 5 per cent glucose in normal saline solution is administered intravenously during the operation. In post-surgical anemia blood transfusions and concentrated liver injections are of considerable value for general "reconditioning" and primary healing.

CONCLUSIONS

1. Mammoplasty with free transplantation of nipple and areola may be considered only after menopause.

2. Mammoplasty with free transplantation of nipple and areola during sex maturity is contraindicated.

3. Mammectomy with free transplantation of nipple and areola is a simple and safe surgical procedure in true hypertrophy and in enormous adiposity of breasts.

4. A two- or more-stage mammoplasty is often contraindicated for psychologic, economic, and possibly esthetic reasons.

5. Transposition of nipple and areola is effective only in atrophic pendulous breasts. The result is not permanent.

6. Transposition of nipple and areola with simultaneous resection is unsatisfactory. The result is not permanent; the scars in the submammary fold are not in accord with modern esthetic standards.

7. All transposition methods produce unsatisfactory and unsightly results, known collectively as the "pancake breast."

8. Resection with transplantation of nipple and areola is surgically safe and esthetically satisfactory.

9. Hypertrophic parenchyma must be resected in the upper medial part of the breast.

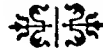
10. When resection between internal mammary and lateral thoracic arteries is adequate, no interference with the blood supply can occur.

11. If additional resection of parenchyma is necessary, the "slanting excision" fully preserves the blood supply of the internal mammary and lateral thoracic arteries.

12. The final skin adjustment is restricted to the vertical mammary line below the areola.

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CHRONIC cystic mastitis is believed to be due to relative excess of the estrogens, producing abnormal duct proliferative activity. While estrogenic treatment has been generally recommended, it does not seem rational unless the dosage is sufficiently large to bring about pituitary inhibition.

From "Textbook of Gynecology" by Emil Novak (The Williams & Wilkins Company).

WAR WOUNDS OF THE ABDOMEN

A REVIEW OF 131 CASES

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MODERN war, with the tremendous concentration of fire power that has been developed on the ground and in the air, has decreased the chances for survival of the soldier who is exposed to it in the front line for any length of time. In the infantry units kept in combat continuously over any period of time so many junior officers were killed that battlefield commissions were given to non-commissioned officers on very frequent occasions. These came to be looked upon gloomily as being tantamount to a sentence of death.

The soldier who was hit by a missile and survived to reach a hospital in World War II, however, had a better chance for survival than was the case in any previous war. This statement seems to be as true for abdominal wounds, with which this report is concerned, as it is for wounds in general.

Before World War I, conservative treatment was generally advised for gunshot wounds of the abdomen. In the Civil War there were 3690 recorded cases of abdominal wounds with a mortality of 90 per cent. In the Spanish-American War, there were forty-four cases reported, of which four were operated upon and all four died. Of the remaining forty that were treated conservatively, twenty-five died, a mortality rate of 62.5 per cent. In the Boer War (1900) and the Russo-Japanese War (1904-1905), the treatment was by starvation and large doses of morphine.¹⁶

Because of such reports, the surgeons in the early days of World War I were of the opinion that practically the only patients who recovered were those who were not operated upon. However, there were some reports from civil life that were more

favorable. Grant, in 1899, collected 253 civilian cases of gunshot wounds of the abdomen in which operation was carried out with a mortality rate of 52 per cent.⁸

From 1857 to 1893, a series of tables of the reported cases of laparotomy done for gunshot wounds of the abdomen was compiled by various authors. In the first series, compiled by Morton, eighteen of the twenty-two laparotomies had been done by Americans. Sir William McCormac who also published a series of collected cases in 1887 perhaps gives a reason for this and reflects the British conception of Americans of that day when he says that gunshot wounds of the intestine are "far from being rare in civil practice, especially in America where everyone carries a revolver and often uses it on small provocation." Be that as it may, the introduction of laparotomy for bullet wounds was definitely an American contribution to surgery.¹⁶

Early in the first World War, Leriche¹⁸ reported that the mortality in abdominal wounds with conservative treatment was over 80 per cent and advised early operation. In 1916, Wallace²¹ reported on 1,200 cases of gunshot wounds of the abdomen among the British Expeditionary Forces. In this group the mortality of the operative cases was 53.9 per cent, not very much less than the total mortality of 60.2 per cent which included the non-operated cases. In 1917, Loekwood and Kennedy¹⁴ reported on 500 cases seen in an advanced casualty clearing station. There were 356 operative cases with a mortality of 51.7 per cent.

Reports in the literature from 1924 to 1943 of a series of civilian cases give operative mortality rates of 48.2, 68, 59.3,

61.4, 53.4, 40, 60.5, 48.9 and 46.4 per cent. Thus it can be seen that the average reported mortality rate for gunshot wounds of the abdomen in civil practice between the two wars was around 50 per cent.^{5,6,9,15,16,17,18,19,20}

Jolly,¹² who operated upon 970 patients with abdominal wounds in the Spanish Civil War of 1936-1939, probably the largest number ever done by an individual surgeon, reported that of 238 cases with injured viscera operated upon, 115 died, a mortality rate of 48 per cent. The rate for his colon wounds was about 60 per cent. He had no sulfonamides or penicillin and did not use gastric suction or the Miller-Abbott tube. He also makes no mention of the procedure of exteriorization for wounds of the colon, either suturing them or doing resections "in spite of the appalling mortality rate."

Reports of the surgical results in gunshot wounds of the abdomen in World War II indicate that a substantial reduction in mortality has been accomplished.

The 131 patients with abdominal wounds, which form the basis of this report, were operated upon by the writer. There were twenty-eight deaths, giving a mortality rate of 21.3 per cent. There were 115 cases which were found upon exploratory laparotomy to have injury to the viscera, and twenty-seven of these died, a mortality rate of 23.4 per cent for those having visceral injuries. Sixteen cases were explored without finding any visceral injury, and one died, a mortality of 6.2 per cent.

The patients operated upon were under the writer's observation for at least seven to ten days postoperatively in most cases before being evacuated to the rear, and experience has shown that in most cases they have either died or are on the road to recovery by the end of this postoperative period. Undoubtedly, there would be some increase in the mortality rate if every one of these patients could be followed through to the end but it would not be great.

Confirmation of this is found in a recent report by Fox⁷ on 270 cases of thoraco-

abdominal wounds treated at a General Hospital. These patients had been evacuated to the General Hospital after undergoing surgery in forward hospitals. Seven patients of the series died, a mortality rate of 2.6 per cent. An indication of the definitive nature of the surgery done in the forward hospitals is the fact that 43 per cent of the patients required no further surgery at the base hospital; 36.3 per cent required only secondary wound closure or skin grafts.

The 131 patients discussed here were operated upon by the writer while he was Chief of a general surgery team of the 4th Auxiliary Surgical Group with the Third Army in the European Theater of Operations. Almost all of them were operated upon in Field Hospitals, the most forward installations where definitive major surgery was performed, the rest in Evacuation Hospitals.

An Auxiliary Surgical Group consisted of surgical teams, e.g., general surgery, thoracic surgery, orthopedic surgery, neurosurgery, maxillofacial, etc., as well as shock teams. A general surgery team in the 4th Auxiliary Surgical Group consisted of a surgeon, an assistant and an anesthetist, a nurse and two enlisted men. As a rule, the general surgery teams were assigned to Field Hospitals while the others worked in Evacuation Hospitals.

Field Hospitals were small surgical hospitals which could accommodate up to seventy-five patients at a time if necessary. The medical personnel of these hospitals were usually not surgeons and were concerned primarily with the administration of the hospital and pre- and postoperative care of the patients under the supervision of the attached surgical teams. The latter were in charge of preoperative, operative and postoperative care of patients. Decisions concerning evacuation of patients was also the responsibility of the surgical teams.

The Field Hospital was attached to the Divisional Clearing Station and was usually set up near or alongside it. During

combat, it received "non-transportable" cases from the clearing station. These were defined as sucking chest wounds, chest wounds with concealed hemorrhage or tension pneumothorax, abdominal wounds with any suspicion of peritoneal penetration and cases with hemorrhage or shock.

The Field Hospital, also, was the most forward installation where whole blood was available for transfusion. During periods of stress when a "back-log" of unoperated cases had developed, whole blood transfusion would relieve hemorrhagic shock and make a case transportable to the rear, if it were not a thoracic or abdominal case.

These hospitals functioned at varying distances from the front lines, sometimes as near as 1,000 yards and occasionally ten to fifteen miles distant, and usually within range of enemy artillery. In accordance with the policy of the Army Medical Corps of "taking the surgeon to the patient," the hospitals had to move frequently and were quite adaptable. Thus, they could function in tents or in almost any type of building or a combination of the two. During the campaign in Normandy, the Brittany peninsula, and northern France, until the middle of December, we operated in tents almost entirely. In Germany and Austria, buildings were usually used and it was found that a satisfactory operating room could be set up in such diverse places as a bier stube, a telephone exchange, a schoolhouse or hotel.

PREOPERATIVE CARE

The preoperative ward of a Field Hospital presented the ultimate picture of the waste of human life and suffering caused by war. When the fighting was intense, the casualties might pour in and a chaotic condition result, causing delay in proper pre- and operative treatment, unless a routine for the preoperative treatment was organized. Experience showed that the use of shock teams was the best way of dealing with this phase. These teams consisted of a medical officer, a nurse and two enlisted men.

When the seriously wounded were brought in they were usually exhausted, very dirty, their clothes torn and mud covered, their faces blackened with gunpowder, dirt and blood. They might be cold and wet. Many of them had been lying in the open in the rain or snow. They might have been carried across a river in a boat, followed by a rough ambulance ride under fire. They were apt to be in intense pain. Respiration might be painful. Many were very young and were frightened. Nearly all of them were suffering from some degree of shock.

The first thing to be done for the patient was to make him dry and warm. The clothing was cut away, moving the patient as little as possible while this was done, and blankets were put under and over him. He was kept on a stretcher which was placed on a cot. Keeping him on a stretcher enabled him to be carried to x-ray and to the operating room without moving him. He was also operated on while still on the stretcher.

The Emergency Medical Tag was inspected to see what the diagnosis was and what the previous treatment had been. It was checked to make sure that he had had his "booster" injection of tetanus toxoid, the amount of plasma that had been given, and, very important for the surgeon, how much morphine he had had and when. In the meantime, the initial blood pressure and pulse readings had been taken. Treatment for shock was then instituted, consisting of the intravenous administration of blood and plasma.

The patient's wounds were then inspected and it was very important, if his condition permitted, to turn him over and look at his back and, in fact, inspect him minutely from head to foot, for the Emergency Medical Tag could be in error as to diagnosis and a wound might have been overlooked. Frequently, the smallest wound was the most serious.

All dressings were removed so that the wounds could be thoroughly inspected. The writer has seen a wound covered up by

a strip of adhesive tape which was holding a dressing on another wound, thus explaining a puzzling absence of a missile on the x-ray film.

All patients with any possibility of an abdominal wound were catheterized and the urine examined grossly, and microscopically if possible, for blood, to rule out injury to the urinary tract. The abdomen was examined carefully in all cases. In any wound of the chest, the missile may have traversed the diaphragm to enter the abdomen and the opposite is also true. Frequently, abdominal tenderness and rigidity are present in chest wounds simulating an intra-abdominal penetration which is not present.

The treatment of shock is the primary consideration in getting patients ready for operation. The blood pressure and pulse are the most reliable guides and were checked frequently. A systolic blood pressure which was brought up to 100 or over and maintained, with slowing of the pulse, was the usual goal before operation.

Early in the war it had been hoped that the use of plasma would be successful in combatting shock from war wounds. It had been advised that if whole blood were used it could be given in the ratio of 2 or 3 parts plasma to one part blood. Experience in the Normandy campaign soon showed, however, that plasma was ineffectual in hemorrhagic shock. Transfusion of whole blood, and in adequate amounts, was necessary to bring patients to a condition to withstand surgery and to support them during and after operation. There can be no rule as to the amounts necessary. The amount necessary means just that, and it depends upon the individual patient.

Whole blood in amounts up to 5,000 and 6,000 cc. has been given with beneficial results. Whenever the tactical situation was such that blood could not be obtained it was immediately reflected in continuing shock, inability to get patients in shape to withstand surgery, and inevitably in increased mortality. Type "O" whole blood flown from the United States was given

without cross-matching in most instances. Reactions to transfusions in the form of chills were frequent but the writer saw no deaths that could definitely be ascribed to transfusion reaction. There is no doubt, however, that they did occur, judging from personal communication with others.

Plasma had frequently been administered at the Battalion Aid Station, Collecting Station, or Clearing Station before the patient arrived at the Field Hospital. There is no doubt that it was useful. It tided the patient over until he could receive blood and in the milder cases it was all that was necessary, and thus saved blood.

While this shock treatment was going on, the patient was started on sulfadiazine and penicillin. Sodium sulfadiazine was given intravenously every eight hours and penicillin every three or four hours. A Levine tube was inserted into the stomach and Wangenstein suction applied.

As soon as the patient's condition warranted it, he was taken to x-ray and anteroposterior and lateral x-rays were taken. In all abdominal wounds, films were taken of the chest, as well as of the abdomen, and vice versa. Much useful information was obtained from these x-rays. The position of the missile or missiles was located and this knowledge, in combination with the position of the wounds, gave the surgeon a fairly accurate idea of the path it had taken and the organs that were probably injured. It also frequently settled the question of whether or not a thoraco-abdominal wound was present.

The transporting of the patient to and from x-ray, together with moving him for positioning while the films were taken, frequently resulted in lowering the blood pressure and increasing the pulse rate, and further shock treatment was necessary before he was considered in optimum condition for operation. Once this optimum period had been reached, however, the operation had best be carried out as soon as possible, for if the patient slipped down into shock again it would be difficult

or impossible to bring him out of it a second time.

OPERATIVE TREATMENT

The patient was brought to the operating tent or room and the stretcher placed on a saw-horse which worked quite well, or if an operating table was used, wooden blocks held the stretcher in place. In most cases the Levine tube was kept in place so that gastric suction might be started immediately postoperatively, and usually did not interfere with the administration of the anesthetic.

Gas-oxygen-ether was used on all abdominal cases, given by the closed system. In cases in which the chest was also involved, intratracheal anesthesia was always used, and it was also used in many of the purely abdominal cases as well.

Electric current was furnished by portable gasoline generators. The operating room lights were "home-made" and of various types, limited only by the ingenuity of the personnel of the hospital. One successful kind was made from headlights salvaged from crashed airplanes, attached to a quadrangle or triangle of wood, and could be moved to focus on the operative field. When the lights went out from the concussion of bombing or other circumstances over which we had no control, flashlights were focussed on the operative field by someone standing by and the operation proceeded.

Many of the patients were in very desperate condition when brought to the operating room in spite of energetic preoperative treatment. This was usually due to very extensive intra-abdominal injuries or multiple injuries, or to continuing hemorrhage. When it was decided that no further improvement could be obtained by anti-shock therapy, they were operated upon if at all feasible, offering the only chance for survival. Some did not, of course, survive, but there were others that seemed hopeless at the time of operation but surprised everyone by pulling through.

Wounds of the back were usually débrided first so that the patient would not have to be turned for this purpose at the end of a long operation. By the same token, if the patient was in poor condition after an abdominal operation and it was judged he would not stand further procedures on other multiple injuries, such as compound fractures of extremities, these were put in traction or plaster splints and débrided at a later date.

If a thoraco-abdominal wound was present and thoracotomy was necessary, this was usually done first and the laparotomy second, if the necessary procedures could not be done through the thoracotomy incision.

The type of incision used was based on the position of the wounds and the x-ray findings. Transverse and subcostal incisions were frequently employed and found very useful. Rectus incisions were of the split muscle type. Mid-line incisions were made in a few instances. In exploring an abdomen for a gunshot wound, it is absolutely necessary to inspect thoroughly every organ in the peritoneal cavity. This is especially true when the victim has been struck by several fragments. In order to do this an adequate incision must be made. The poor lighting under which most of this work was done also made fairly long incisions necessary. Usually upon opening the peritoneum, the cavity was found filled with blood clots and frequently gross feces. We usually had suction, sometimes made available by placing a truck with its motor running outside the tent and running a tube to the windshield wiper.

After sucking and mopping out the peritoneal cavity, active bleeding was looked for. Then the small intestine was inspected in its entirety and all perforations tagged with clamps. The small intestine was then eviscerated while the other organs within the peritoneal cavity were inspected. This is an important time-saving procedure and here again an adequate incision is necessary or the small gut will become markedly congested while it is being held outside.

Injuries of the large bowel may be very deceptive and hard to find, and it is absolutely imperative that the operator be sure whether or not there are any perforations in it. Lacerations of the mesenteric border and retroperitoneal lesions must be searched for, if suspected; and it may be necessary to mobilize a considerable portion of the bowel to find the lesion or convince oneself that there is none present. The writer has noted on several occasions when a retroperitoneal hematoma was present, the presence of emphysema under the peritoneum, lateral to the descending or ascending colon, probably due to colonic gas, which has led to the discovery of a retroperitoneal laceration of the large bowel.

When a penetrating wound of the anterior wall of the stomach is present, the gastrocolic omentum should be incised and the posterior wall inspected. If there is still doubt, an anterior gastrotomy may be done and the missile searched for within the lumen of the stomach.

In any instance in which the retroperitoneal spaces have been opened in the presence of contamination, they should be drained posteriorly through a stab wound. This is also true of kidney or ureteral injury when a nephrectomy has not been done.

Injuries of the colon were treated by exteriorization in nearly all cases. Small intestinal injuries were repaired if at all possible. If not, resection and primary anastomosis was done, usually end-to-end.

Injuries of the infra- and retroperitoneal portions of the rectum are very serious unless treated properly in the beginning. The diagnosis may be made by digital examination, proctoscopy or deduced from the course of the missile. Usually it is necessary to perform an exploratory laparotomy, at which time a colostomy is done. The patient is then turned over and a coccygectomy done, the fascia propria incised and the whole retrorectal space widely opened and drained. If the laceration is seen, it should be repaired. All

colostomies should be made through separate stab wounds if possible and time permits.

Wounds of the liver had usually stopped bleeding when the abdomen was opened. If bleeding was present, it might be necessary to pack the liver. Lacerations of the liver were usually not sutured. It was believed that drainage of bile and necrotic liver tissue from the tract would be blocked by suturing. It is better not to suture the liver but to place drains down to the liver lacerations to give egress to bile and prevent the formation of bile peritonitis and bile cysts.

Lacerations of the duodenum are difficult to repair and are usually associated with other grave injuries. The duodenum must be mobilized adequately to get at least a two-layer closure, preferably three.

Lacerations of the gallbladder were treated by cholecystostomy as there were other injuries to be taken care of, and it is simpler and quicker. The writer saw one case of laceration of the gallbladder with other visceral injuries which also had an anterior perforating ulcer of the second portion of the duodenum, which had perforated to, but not through, the peritoneum.

Extreme conservatism was used in treating wounds of the kidney. Nephrectomy was done only when the kidney was grossly fragmented or there was continued bleeding from the renal vessels. Extraperitoneal drainage to the kidney area was provided through a flank incision. It was believed that by this policy many kidneys were saved, and that if nephrectomy was necessary, it could always be done later.

Bladder wounds were treated by doing a suprapubic cystostomy and suturing the lacerations. Occasionally, the bladder was injured entirely extraperitoneally, and no injury would be seen at laparotomy. Here the course of the missile, plus the presence of blood in the urine, will prompt the operator to search for a bladder laceration. When comminuted fractures of the pelvis are present, bone fragments may be in the bladder and other sharp fragments may be

impinging on the bladder or be sticking part-way through the bladder wall. These should be removed and the bone made smooth. After the bladder had been cleared out and the lacerations sutured, the cystostomy opening was closed about a mushroom catheter and the prevesical space was drained.

At the close of abdominal operations where there had been intestinal injuries with contamination, 5 gm. of sulfanilamide, mixed with 100,000 units of penicillin powder, was dusted into the peritoneal cavity and the layers of the abdominal wall. No intraperitoneal drainage was used except in the presence of liver, pancreatic and duodenal injuries.

All entrance and exit wounds were thoroughly débrided and loosely packed. The abdominal incisions were closed in layers. The peritoneum was closed with a single running catgut suture. Tension sutures of heavy silk were then inserted through all layers, including a bite of the peritoneum. The fascia was closed with interrupted chromic catgut sutures. The skin was then closed or not, depending upon the degree of contamination. In the presence of fecal contamination, the wound was packed to the fascia with vaseline gauze, and the tension sutures tied over it.

Infection was certainly not a factor in the postoperative course of the great majority of these patients while under observation in Field Hospitals. Little or no evidence of postoperative peritonitis was observed in nearly all the autopsies seen by the writer upon patients who died from a few days to two or more weeks after operation in which fecal contamination had occurred. The chemotherapy used in the whole course of the treatment seems to be the major factor in producing such amazing results. I would add that penicillin seems to be the most important single factor. Other surgeons have reported similar results with the use of penicillin alone, the sulfonamide drugs not being used at all (personal communication).

POSTOPERATIVE CARE

At the end of the operation the patient was sucked out with an intratracheal catheter, if necessary, until dry and taken to the postoperative ward. He was not moved from the stretcher. The operative procedure had frequently been long and it was necessary to observe the patient closely in the immediate postoperative period. Oxygen was given frequently, usually by nasal catheter. Wangensteen suction was applied. Frequently blood was given. Occasionally, a patient would lapse into secondary shock. Concentrated serum albumin was found to be useful in this emergency, although it was often not available. Patients with chest wounds were put in a sitting-up position when possible.

Parenteral fluids were given; a minimum of 3,000 cc. a day, until the patient could take fluids by mouth. These fluids consisted of 1,000 cc. of plasma, 1,000 cc. of physiologic saline, and 1,000 cc. of 5 per cent glucose in distilled water. Fluids lost by gastric suction were replaced by intravenous saline. Whole blood was given when indicated and was very useful to give the patient a boost several days after the operation. It was surprising how many of the patients responded promptly postoperatively. Illustrative of this was one early in our experience who had had a lacerated stomach and small intestine with a very massive intraperitoneal hemorrhage who complained bitterly twenty-four hours after he had been operated upon because he was not allowed to get in the "chow line."

The Influence upon Mortality of the Time Interval between Wound and Operation. (Table 1.) The average time interval between wound and operation was 9.7 hours and ranged from two hours to four or five days. Table 1 shows the mortality rates for the 121 cases in which the time factor was known and these are compared with rates for similar intervals in cases with hollow viscus perforation. The difference is not very great and bears out the impres-

TABLE I
TIME INTERVAL BETWEEN WOUND AND OPERATION
121 CASES IN WHICH THE TIME INTERVAL IS KNOWN

Hours	All Cases				Cases with Hollow Viscus Perforations			
	No. of Cases	Incidence	Deaths	Mortality Per Cent	No. of Cases	Incidence	Deaths	Mortality Per Cent
1-4	12	9%	0	0	6	6.9%	0	0
4-8	44	36%	10	22.7	32	36%	7	21.5
8-12	36	29%	10	27.7	25	28%	9	36
12-18	17	14%	2	11.7	12	13%	2	16.6
18-24	6	4.9%	2	33.3	6	6%	2	33.3
24-36	4	3%	1	25	4	4%	1	25
36-48	0	0	0	0	0	0	0	0
48-72	1	.8%	0	0	1	1%	0	0
72+	1	.8%	1	100	1	1%	1	100
	121		26	21	87		22	25

sion that infection is not the most important factor in influencing mortality in war wounds treated with modern methods of chemotherapy. Patients operated upon between four and twelve hours after being wounded comprise sixty-five per cent of the total. There are several reasons for this

TABLE II
MISSILES

Type	No. of Cases	Per Cent
Shell fragment.....	90	69.2
Bullet.....	38	29.2
Knife.....	2	1.5

time lag, among them being difficulty of transportation under blackout and in bad weather, rushes of casualties with the development of a backlog, the difficulty of keeping up with the swiftly advancing armored units and other tactical reasons.

Missiles. (Table II.) The missile was a shell fragment in ninety cases or 69.2 per cent of the 130 cases in which it was known. These fragments came from artillery shells, aerial bombs, mortars and hand grenades. Thirty-eight patients, or 29.2 per cent were struck by bullets from rifle, machine gun or pistol. Knife wounds occurred in two

cases or 1.5 per cent. These were long trench knives and were driven in very deeply.

Cases in Which No Visceral Lesions Occurred. There were sixteen cases in which exploratory laparotomy was performed and no visceral lesion found with one death, a mortality rate of 6.2 per cent. These operations were done in cases in which the presence of a visceral injury could not be ruled out. In some the peritoneum had been penetrated or perforated without injury to a viscus.

In several the missile had entered through the chest and appeared to be in the peritoneal cavity. In two cases the missile was found to be in the muscle of the diaphragm, not having gone through it. Others were found to have retroperitoneal hematomas which can cause marked abdominal signs. Some of these were so extensive as to threaten the blood supply of the large bowel so that a colostomy was done. The one patient who died had a peritoneal hematoma, quite extensive, and was operated upon at a time when the enemy had us cut off to the rear so that we could not obtain blood in adequate amounts and it was believed that lack of blood contributed materially to his death.

Many parietal abdominal wounds were explored and if it could be definitely

determined that the peritoneum had not been penetrated, a laparotomy was not done. Such cases are not included in this report.

TABLE III
THE INFLUENCE OF THE SEVERITY OF INJURY UPON THE MORTALITY RATE

Nature of Injury	No. of Cases	Deaths	Mortality Rate Per Cent
Thoraco-abdominal wounds...	18	8	44.4
Stomach and other viscera....	8	4	50
Small intestine alone.....	25	3	12
Small intestine and other viscera.....	35	11	31
Colon alone.....	10	1	10
Colon and other viscera.....	34	10	29
Liver alone.....	8	0	0
Liver and other viscera.....	16	6	37.5
Kidney alone.....	1	0	0
Kidney and other viscera.....	12	5	41.6
Bladder alone.....	4	0	0
Bladder with other viscera....	6	1	16.6
Abdominal wounds with associated compound fractures	40	12	30
Abdominal wounds with associated compound fractures of the femur.....	5	3	60

Multiple Injuries. There were sixty-five abdominal wounds with associated multiple injuries, an incidence of forty-nine per cent. In this group there were fifteen deaths or a mortality rate of twenty-three per cent. This is about the same as the rate for the entire series. Those with associated multiple soft tissue injuries even had a lower mortality, there being twenty-five such cases with three deaths, a mortality of twelve per cent. Associated compound fractures, however, increased the risk, especially fractures of the femur which gave a grave prognosis. Thus, there were forty cases with associated fractures with twelve deaths, a mortality of 30 per cent, and five cases with associated fractures of the femur with three deaths, a mortality rate of 60 per cent.

Multiple injuries of viscera decreased the individual's chance for survival. By the

same token, severity of injury, which is hard to represent statistically, is the most important factor of all in producing mortality. (Table III.)

Thoraco-abdominal Wounds. This is a severe injury, involving as it does both the pleural and peritoneal cavities and the viscera contained in them as well as a laceration of the diaphragm. Some of the abdominal cases had also an associated chest wound with no involvement of the diaphragm, but these are not considered true thoraco-abdominal wounds and are included among the abdominal wounds with associated multiple injuries.

There were eighteen thoraco-abdominal wounds with eight deaths, a mortality rate of 44.4 per cent. Ten were left-sided with five deaths, a rate of 50 per cent, and eight were on the right side with three deaths, a mortality of 37 per cent. The ones on the left side are usually the most serious, often necessitating a splenectomy and frequently involving the stomach and splenic flexure of the colon which are in close proximity to the diaphragm.

The type of operative approach in these wounds varied with the size of the wounds, the direction and path of the missile, and the side on which the wound occurred. The thoracic approach is almost mandatory on the right side, for it is difficult to repair the diaphragm on that side from below because the liver is in the way. However, it is necessary to make an additional abdominal incision if an exploration of the peritoneal cavity is required. On the left side the entire procedure can often be done through the thoracotomy incision. This is the easiest method of doing a splenectomy and a quite extensive exploration of the peritoneal cavity can be done through the left diaphragm. Colostomy for large bowel injuries can be done through a stab wound.

An advantage of a thoracic incision also is that injuries of the thoracic viscera can be visualized and repaired if necessary. If an abdominal approach was employed, the subcostal incision was frequently found

TABLE IV
ANALYSIS OF DEATHS

Cause of Death	Cases	Remarks
Shock.....	13	All these patients were suffering from shock before and during the operation. Some died within a few hours after the operation and one died on the table while the peritoneum was being closed. Three died at a time when blood was unavailable in adequate amounts and it was believed that this was a major factor
Shock and sepsis...	3	These patients all had marked peritonitis at time of operation: two had bile peritonitis and one had extensive fecal peritoneal soiling. Two had been wounded 24 hr. or more before operation
Pulmonary complications	4	Two died from pneumonia and atelectasis. One had severe asthma and ischemic necrosis of one-half of one kidney from lacer. of a branch of a renal artery. One had a chest wound and bilateral pneumonia with fibrinous pleurisy on one side
Embolism.....	4	These were sudden deaths. One died 11 days postop. after developing hemiplegia. One, 4 days postop., pulmonary embolism. One died on the operating table from air embolism accidentally injected during a blood transfusion. One presumable fat embolism from an associated extensive fracture of the femur and pelvis
Infection.....	1	Extensive phlegmon of pararectal region
Intestinal obstruction	1	Multiple angulations of the small intestine which had 17 perforations
Mesenteric thrombosis	1	Ten days postop. after resection of 36 inches of small gut and two colostomies. Very gross fecal soiling at time of operation. No peritonitis at autopsy
Respiratory or cardiac reflex (?)	1	A transthoracic splenectomy in excellent condition at end of oper. Died suddenly when turned on back at end of operation
Total.....	28	

useful; and in one case the thoracic incision was extended to make a combined thoraco-abdominal incision.

Wounds of the Stomach. There were nine cases in which the stomach was injured with five deaths, a mortality of 55 per cent. In only one case was the stomach alone injured and the patient died. The missile in this case was a small flat fragment, 1 cm. in length, which had perforated his winter clothing, the anterior abdominal wall, the anterior stomach wall, and was found imbedded in the mucous membrane of the posterior stomach wall. This was comparatively a trivial abdominal wound but the patient died within twenty-four hours of a massive bilateral pneumonia and atelectasis. Upon reviewing the pre-operative chest x-rays, it was believed he had a diffuse virus pneumonia before operation.

Duodenum. There were two cases with duodenal wounds, both complete transections of the second portion, with very grave associated injuries. A three-layer closure was done in each case but both patients died. One had, beside multiple small intestinal injuries, fractures of four vertebrae with transection of the spinal cord, and the other had lacerations of the lung, liver, left kidney and right ureter.

Small Intestine. Injuries of the small intestine were almost always accompanied by massive intraperitoneal hemorrhage, which had ceased by the time operation was done. A very characteristic feature of this injury is the marked pouting and eversion of the mucous membrane which tends to close the opening or make it smaller, thus diminishing the amount of intestinal contents spilled into the peritoneal cavity. Realizing that resection carries a higher mortality than suture alone, it was only done when the lacerations were so extensive, ragged and confluent that repair was impossible, or the mesentery was injured and stripped away so that the blood supply of the gut was lost.

There was a total of sixty cases in which the small intestine was injured with four-

teen deaths, a mortality rate of twenty-three per cent. Of these the small intestine alone was injured in twenty-five cases with three deaths, a rate of 12 per cent. There were thirty-five cases of small gut injury with associated injury to other viscera with eleven deaths, a rate of 31 per cent.

There were eleven cases in which resection and anastomosis was done with four deaths, a rate of 36.3 per cent. The average number of lacerations of the small gut was 4.8, ranging from a single one to seventeen, the highest number counted.

Wounds of the Large Intestine. Lacerations of the colon were treated by exteriorization, except in a few cases with small lesions which were sutured. Nearly all the colostomies were of the Mikulicz type at first, but later loop colostomies were done entirely, due to reports from General Hospitals, where the closures were being done, that difficulties were being encountered in the ones with spurs. Wounds of the pelvic colon which could not be brought out were repaired, and a proximal colostomy done.

Wounds of the infraperitoneal portion of the rectum were treated by coccygectomy and drainage. Injuries of the colon occurred in forty-four cases with eleven deaths, a mortality rate of 25 per cent. There were ten cases in which the colon alone was injured with one death, or 10 per cent. The colon injury was associated with injuries to other viscera in thirty-four cases with ten deaths, a rate of 29 per cent. There were three cases with injury to the rectum below the peritoneum with one death.

Kidney Injuries. There was one patient with injury to the kidney alone and he survived. In twelve cases there was injury to the kidney plus other associated visceral injuries. Five of these died or 41.6 per cent. Two nephrectomies were done with one death.

Urinary Bladder. There were ten cases with injury to the bladder with one death, a rate of 10 per cent. Four cases had no other visceral injuries, and none of these

died, the death occurring among the six with other visceral injuries.

Liver. There were twenty-four cases with lacerations of the liver with six deaths, a mortality rate of 25 per cent. Eight cases were injuries of the liver alone and none of these died, while the six deaths in the sixteen with other visceral lesions gives a mortality rate in this group of 37.5 per cent.

Spleen. There were six cases with injury to the spleen severe enough to require splenectomy. Three of these patients died, giving an operative mortality in this series of 50 per cent.

Pancreas. No pancreatic injuries severe enough to be recorded were seen in this series. Several were seen at autopsy in patients who died without operation. These lesions are usually associated with other grave injuries, so that few of them ever reach the operating table or even the hospital.

SUMMARY

A report of 131 war wounds of the abdomen, operated upon in Field and Evacuation Hospitals in the European Theater of Operations, is presented. The data compiled from this group of cases indicate that the mortality from abdominal wounds in World War II is not greatly influenced by the time lag between injury and operation as has been the case in the past. This is probably largely due to the control of infection by present methods of chemotherapy. The severity of injury, as represented by the extent and multiplicity of visceral lesions, is the major factor influencing mortality in this series. The mortality rates are similar to others reported in the recent war and indicate a marked reduction as compared with the mortality rates of previous conflicts.

The writer wishes to express his thanks and appreciation for their devotion, loyalty and hard work to the following who were members of his surgical team, some for varying lengths of time: Capt. D. W. Ovitt, Capt. Donald Ross, 1st. Lt. Ada F. Bennett, ANC., Capt. Stanley Yudicky, Capt. Samuel Cohen, Capt. C. R. Schroder, T/4 David Coltman and T/4 Melvin Coulter.

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THE FOOT PROBLEM AS SEEN IN SOLDIERS*

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THE soldier's foot is of very important military consideration since a soldier with a painful foot cannot march and is therefore of little value. The causes of painful feet in soldiers are innumerable and it is not possible to discuss them all thoroughly. The various foot conditions will be enumerated and only the more common ones will be described.

In order to treat a painful foot properly, one must be able to recognize and evaluate the clinical findings present. A proper concept of the anatomy and physiology of the foot is a prerequisite to proper diagnosis and therapy. An adequate history must be obtained and examination made to determine the etiological factor present. Systemic causes for painful feet must not be overlooked.

In order to cope with the foot problem in soldiers, prophylactic measures must be employed to prevent disabling symptoms. These consist of adequate shoe and sock requirements as well as general care of the feet.

THE SHOE

Requirements. A well formed correct military shoe should have: (1) a straight last, (2) a narrow heel and broad toe, (3) a shank of moderate width, (4) a non-irritating counter and (5) soles made of leather; rubber soles are undesirable.

Fitting. Shoes are fitted by one of two methods: (1) by a machine which measures the foot during weight bearing; (2) by hand; shoes should be $\frac{3}{4}$ inch longer than the foot during weight bearing and sufficiently wide to avoid crowding the toes.

Care of Shoes. After an accurate shoe fit is obtained, proper care must be given them in order to assure continued comfort: (1) Shoes trees should be used when possible. (2) Shoes should be dried into proper shape when wet. (3) The lining of shoes should be smooth.

"Breaking in" of New Shoes. When properly performed, this will prevent many foot ailments. New shoes can be "broken in" by one of two methods: (1) Waterproof shoes in oil; this is not good for perspiring feet. (2) Stand in water for five minutes and then walk around until the shoes dry on the feet.

Care of Hosiery. Proper care of hosiery is also important to avoid a painful foot. (1) Light weight woolen socks are best. (2) Hose should fit well. Socks should not be short but should be of proper length. (3) Socks should be changed daily.

Care of the Feet in General. In addition to wearing properly fitted shoes and socks, the soldier must give his feet essential prophylactic care in order to prevent painful disabilities: (1) Bathe the feet regularly. (2) Dry them well between the toes. (3) Expose the feet to the sun regularly. (4) Prevent chafing by use of foot powder

FOOT CONDITIONS COMMONLY FOUND IN SOLDIERS

I. *Blisters and Abrasions.* These are due to irritation from socks and lining of shoes. They are treated by opening the blisters aseptically through healthy area and applying a dressing.

II. *Ingrown Toe Nails.* The lateral edge of the nail curls downward and becomes

* Presented to the AAF Twelfth Regional Orthopedic-Fracture Conference at Duke University, Durham, N. C., November 27, 1943. The patients referred to were treated at Station Hospital, Camp Mackall, N. C.

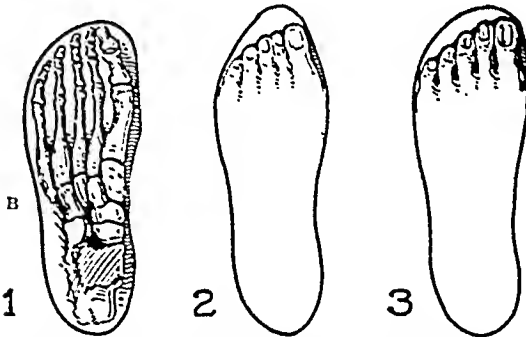
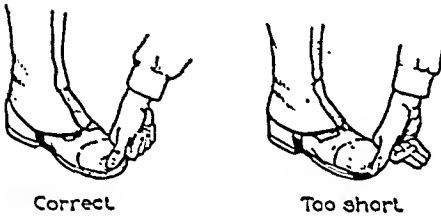
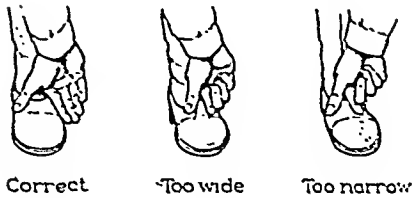


FIG. 1. A, shoe fitting. Shoes should be $\frac{3}{4}$ inch longer than the weight bearing foot and wide enough to avoid crowding the toes. B, anatomical study of shoe fitting: 1, effect of too short a shoe; 2, effect of pointed toe shoe; 3, a good foot in a well fitted shoe. (From *The Military Medical Manual*, 5th ed., courtesy of The Military Service Publishing Co.)

embedded in the adjacent soft tissue. Inflammation and secondary infection ensue. These are caused by short, narrow shoes, short, tight socks, or improper cutting of nail. In early cases elevate the nail edge by inserting cotton pledget under it. In late, infected cases, excise the lateral nail margin with its matrix

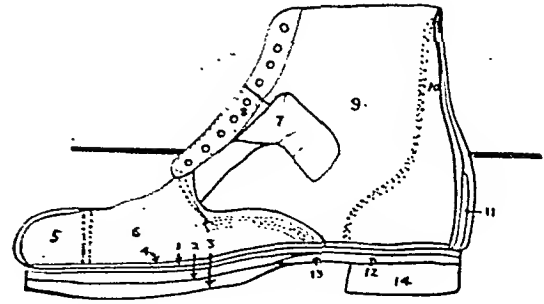


FIG. 2. Construction of a shoe as seen in longitudinal section: 1, welt; 2, slip-sole; 3, outer sole; 4, insole; 5, toe cap; 6, vamp; 7, tongue; 8, eyelet facing; 9, quarter; 10, backstay; 11, counter; 12, heel seat; 13, shank; 14, heel.

and adjacent inflamed soft tissue. Apply vaseline gauze dressing.

iii. *Subungual Hemorrhage*. These are due to an injury, usually from a falling object. Treatment involves drilling the nail and releasing the blood.

iv. *Hangnails and Paronychia*. When infection is present incision and drainage is indicated.

v. *Cracks and Fissures*. These are common between the toes, due to perspiration, or when the toes are not dried after bathing. Antiseptic powders are useful as a prophylactic. They cake and irritate when applied to the fissure. Powders are Army foot powder and zinc stearate. Dyes such as gentian violet can be used; and if adjacent callous is present, excise it.

vi. *Corns and Callouses*. These hypertrophic areas of the horny layer of the skin are very common among soldiers. Hard corns are usually present over the dorsal aspect of the toes and are due to shoe pressure. Treatment involves relief of pressure by properly fitted shoes; the application of a doughnut-shaped felt pad; the shaving off of hyperkeratotic area, or the excision of the corn *in toto*.

Soft corns are usually present on the interdigital surface of the toes and are caused by irritation from a spur or lipping on the adjacent phalanx, as well as by perspiration. Treatment includes the keeping of the interdigital space clean and

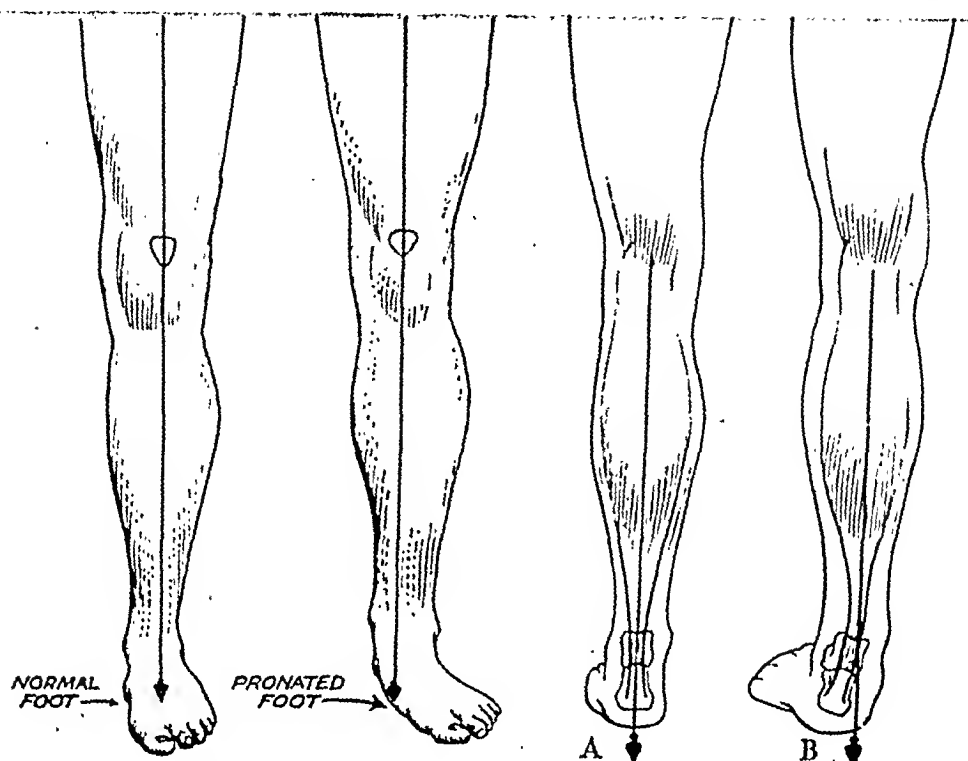


FIG. 3. Relation anteriorly of plumb line dropped from middle of patella to the normal and flat foot; similar relation of plumb line dropped from middle of popliteal space to normal A and flat-foot B. (LEWIN, Courtesy of Am. Jr. Dis. Child.)

dry with alcohol and powder; the application of a felt pad between the toes to prevent pressure over the corn. Excision of bony spur when present should be carried out. If infected, hot boric acid foot soaks should be employed.

VII. Bromidrosis. Excessive perspiration may be due to overweight or glandular disturbance. This can be counteracted by local applications of 25 per cent aluminum chloride solution applied for three successive nights at weekly intervals, frequent foot baths, and the application of army dusting powder.

VIII. Athletes Foot, (Epidermophytosis). This condition is very common among soldiers. It is due to a fungus infection and is manifested by itching, vesicle formation, and maceration of the skin between the toes. The nails become ridged and keratotic. Scrapings from the lesion are placed in 20 to 30 per cent potassium hydroxide and examined microscopically for spore or chain-like or-

ganisms. Prophylaxis includes: (1) Avoid walking barefooted; wear wooden shoes in shower; (2) employ foot bath of 10 to 15 per cent cadum sodium thiosulfate before entering shower; (3) avoid woolen socks and change socks daily.

Treatment involves: (1) Keeping the feet clean and dry; (2) local applications of Whitfield's ointment; dyes such as gentian violet; dusting powders; (3) ultra violet ray or sunlight exposure of feet; (4) avoiding spread of infection to other parts of the body; and (5) boiling socks and changing them daily.

IX. Static Disability of the Foot. The bulk of soldiers seen with painful feet fall into this category. Static foot deformities consist of flat feet, metatarsalgia, and March fracture.

FLAT FEET

The etiology may be hereditary, associated with fusion of the tarsal bones or presence of an accessory scaphoid, trau-



FIG. 4. A. T., twenty-one years of age, march fracture, second left metatarsal, mid-shaft. Onset of pain after prolonged drill session end of May, 1943; foot strapped without relief; hospitalized June 16, 1943. A, June 7, 1943, incomplete oblique fracture line, second left metatarsal, mid-shaft; B, June 14, 1943, mild periosteal proliferation; C, June 21, 1943, marked increase of periosteal proliferation; irregular shaggy outline of callus; D, June 28, 1943, more regular outline of callus; E, July 5, 1943, ossification of callus; trabeculation present. Treated with bed rest; returned to duty July 6, 1943, with shoe correction.

matic or postural, with or without associated obesity and glandular disturbance. Regardless of the underlying cause, however, the problem confronting us is to differentiate the symptomatic from the painless flat foot. In a large percentage of cases, the complaints of the patient are unreliable. It is common knowledge that the height and shape of the longitudinal arch do not completely determine the strength or usefulness of the foot. Yet a large number of soldiers have come to realize that a plano-valgus position of the foot is a possible invitation to a C.D.D. We must recognize and evaluate the objective findings in order to dispose properly of a case of pes planus. Is there pronation of the foot with inward rotation of the astragalus and os calcis, resulting

in lateral inclination of the achilles tendon? Is there peroneal spasm or actual contracture with restricted mobility of the foot? Are callouses present to indicate abnormal weight bearing? If so, the patient's complaints of pain, fatigue, and tenderness under the calcaneo-scapoid or spring ligament may be justified.

Mild or moderate cases are treated with shoe corrections, arch supports and corrective exercises as follows:

Shoe Corrections. A Thomas heel can be used (inner border lengthened to scaphoid tubercle and elevated one-eighth to one-quarter inch). Longitudinal cookies or scaphoid pads can be inserted. Either the rigid or flexible arch supports may be used. Exercises are all important in order to strengthen the muscles which help

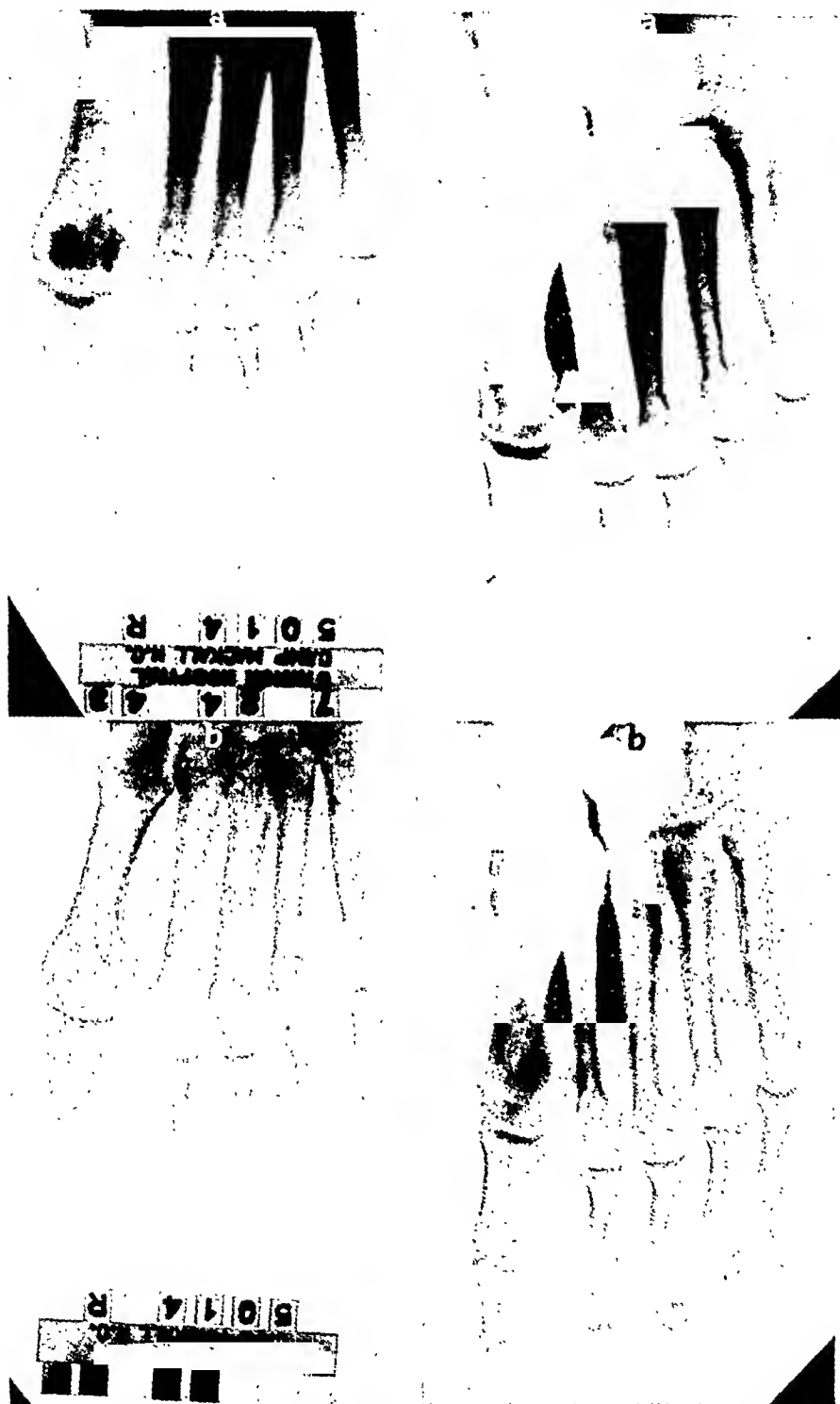


FIG. 5. D. M., nineteen years of age, parachute jump fracture, neck of second, third and fourth metatarsals, right, accidentally incurred July 23, 1943. A, July 24, 1943, note fractures at neck of second, third and fourth metatarsals; B, August 30, 1943, practically no external callus noted; union clinically; treated by immediate hospitalization and plaster of Paris cast for five weeks; returned to duty with shoe correction.

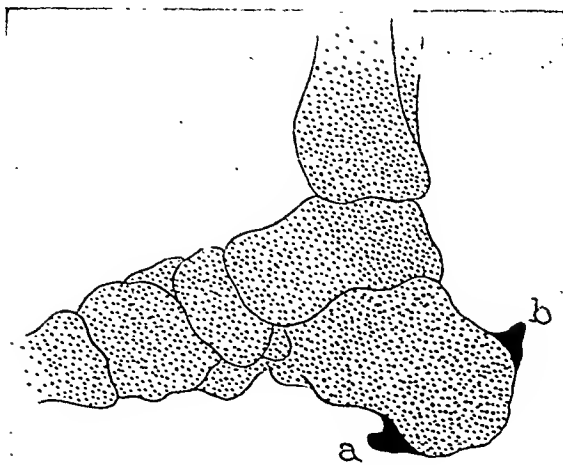


FIG. 6. Exostosis of os calcis with (a) ordinary calcaneal spur and (b) exostosis at postero-superior angle. (LEWIN "The Foot and Ankle," Courtesy of Lea and Febiger.)

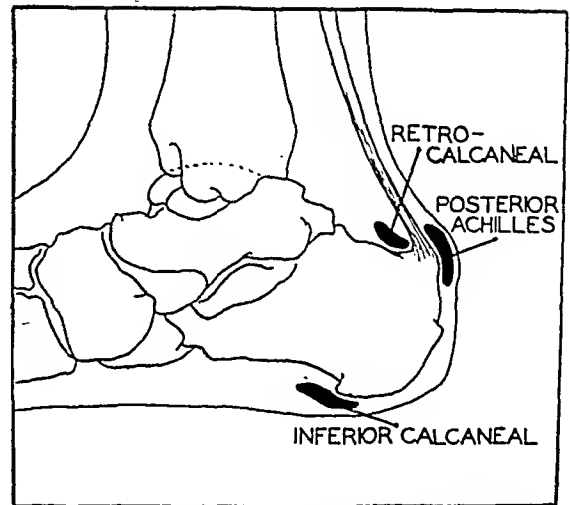


FIG. 7. Bursae of the heel. Note the inferior calcaneal spur. (SHANDS. "Handbook of Orthopedic Surgery," courtesy of C. V. Mosby Co.)

elevate the arch. They require only a few minutes and some of them can be performed even with the shoes on. They do give a measure of relief. These are: (1) Standing position; elevate the arch by inverting the hindfoot while the forefoot is maintained flat on the floor. (2) Sitting position with legs crossed; actively invert and dorsiflex the suspended foot. (3) Sitting position; pick up marbles with the toes; then invert and dorsiflex the foot and carry the marble to the front of the opposite foot. (4) Walk on supination board. (5) Stretch short achilles tendon. Standing, with one foot advanced in the thrust position. Completely extend the hind knee with the foot flat on the floor.

Attempt is made to return these mild cases to regular duty after the above rehabilitation has been carried out. Frequently, this is not possible, whereupon these patients are placed on duty without field service. Many of these mild cases persist in their complaints and even develop other complaints without organic basis. The psychiatrist labels these cases psychoneurotic and the patients accomplish their aim by receiving an honorable discharge.

Severe cases with peroneal spasm and rigidity of the foot, or cases with marked

eversion with inward rotation of the astragalus and os calcis are recommended for C.D.D. in accordance with Circular #164 and MR 1-9. Surgical procedures such as section of the peroneal tendons; the Miller operation with fusion of the joints between the scaphoid, internal cuneiform and base of the first metatarsal bones; the Hoke operation with fusion of the scaphoid, internal and middle cuneiform bones; and the Zadek operation with subastragalar wedge resection and arthrodesis are not carried out in the Army.

METATARSAL ARCH DEFECTS

Static depression of the metatarsal arch is usually associated with pes planus. The abnormal weight bearing results in callous formation, pressure on the interdigital nerves and bursitis. Injury may result in a similar defect. When heredity is the etiological factor, pes cavus or Morton's syndrome may also be present.

The patient complains of pain on prolonged weight bearing. The obvious depression of the metatarsal arch, the tendency to claw-toe, and the callous formation under the metatarsal heads confirm the symptoms. The findings are more marked in the cavus foot.

Treatment at our hospital consists of the shoe corrections, supports and exercises



FIG. 8. M. P., twenty years of age, Freiberg's infraction, third left metatarsal. Note broadening, irregularity and flattening of metatarsal head. Two small osteochondral bodies are present within the metatarsophalangeal joint. Injury in 1939; disposition; duty without field service; shoe correction.

outlined for pes planus, with the addition of transverse bars applied to the shoes. In cases in which fixed hammer toe is present, tenotomy of the flexor and extensor tendons with plantar capsulotomy at the interphalangeal joint will correct the deformity. Surgery of hammer toes, however, is not recommended in the Army. The possibility that short shoes may be an etiological factor should be investigated and corrected if necessary.

MARCH FRACTURE

This condition is very prevalent at our Camp where twenty-five mile hikes and double-timing are popular outdoor sports. The history is quite typical. During or following a long march, the patient experiences pain in the forefoot. Rest overnight gives him some relief, and he attempts to continue on duty. Persistent

and accentuated pain, however, brings him to the dispensary. X-rays are taken, found to be negative, and the foot is therefore strapped to relieve a supposed sprain. The symptoms continue with further weight bearing, and some time later check-up x-rays reveal a fracture line or proliferative periostitis. Clinically, local enlargement and tenderness are noted, and the patient is hospitalized.

Serial x-rays have unfolded an interesting, progressive, gross pathological process. The original roentgenograms are either negative, reveal an infraction, or a complete fracture even with some displacement. In one case the fracture was comminuted. The fracture line may be present at any level of the metatarsal bone from the base to the neck. In the majority of instances, however, the mid shaft is involved. The third right metatarsal was

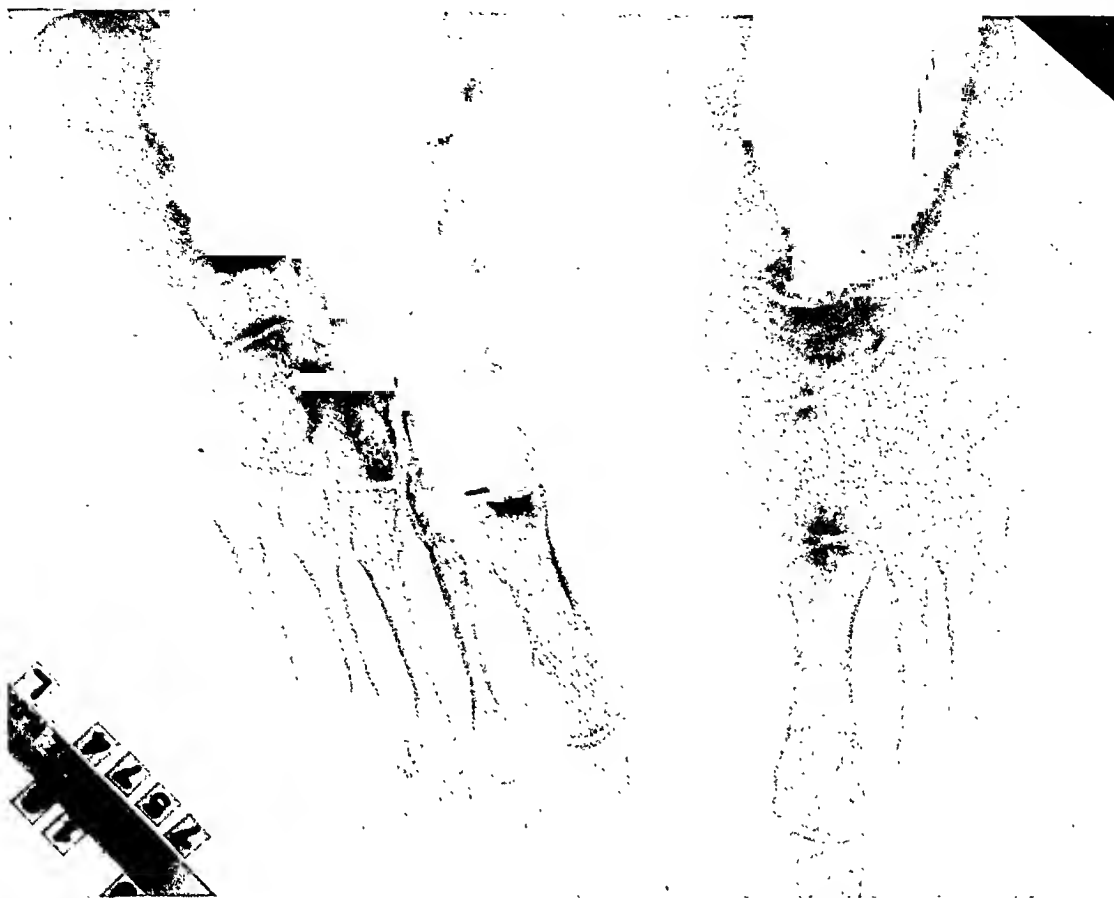


FIG. 9. L. T., twenty-five years of age, pes planus 3° , bilateral; hypertrophic arthritis, astragalo-sephoid joint, bilateral, with deformity of head of astragalus and body of sephoid. Disposition; C.D.D.

most commonly involved; the right and left second metatarsals were equally involved and almost as frequently as the third right. Generally the fracture line was indistinct at first, with little or no periosteal proliferation. Subsequent films revealed increase of periosteal callus with shaggy, irregular outline. Bone resorption at the fracture site was also noted in the later films, causing the fracture line to become wider and more distinct. Final x-rays revealed complete ossification of the newly formed callus with regular and distinct outline. The fracture line again became narrowed or completely obliterated. The degree of fracture, the amount of resorption at the fracture site, and the amount of callus subsequently formed are dependent upon how soon the patient is taken off active duty status following the appearance of symptoms and confined to bed. When weight bearing is continued

for days after the onset of symptoms, one can expect marked x-ray changes, even if the original roentgenograms are negative. When confinement to bed is carried out immediately after the symptoms appear, the x-ray changes are minimal.

Treatment. The proper management of March fracture requires its early recognition. Unprotected weight bearing should be discontinued as soon as the symptoms appear. Do not wait for positive x-ray findings. Clinical evidence should be sufficient to make a presumptive diagnosis of probable March fracture. A history of a long march with resultant pain and tenderness over one or more metatarsal bones, with local soft tissue swelling, and with or without palpable local bony enlargement is enough evidence to warrant confining the patient to bed. Subsequent roentgenograms will reveal the fracture

line and periosteal proliferation. The earlier the patient discontinues weight bearing, the less tendency will there be for excessive callus to form; the less tendency will there be for bone resorption to occur at the fracture site; and the earlier will complete ossification of the callus take place. The entire cycle of the entity will therefore be shortened and the patient will be able to return to his duties at an earlier date. The ideal method of treatment therefore is to confine the patient to bed with or without plaster of Paris immobilization for about three weeks. Avoidance of weight bearing is the important factor. In cases of multiple fracture of the metatarsal bones, the foot should be immobilized in a plaster of Paris cast to prevent deformity. The patient should not be permitted to resume weight bearing until the x-rays reveal subsidence of periosteal proliferation and complete ossification of the callus present. This is evident when the shaggy, irregular appearance of the early callus takes on a regular, smooth and distinct outline with trabeculation characteristic of ossification. Weight bearing may then be permitted with shoe correction. Transverse bars are fixed to the shoes, and in some cases, Thomas heels and longitudinal cookies are also applied. All of our patients have returned to regular duty. The length of temporary disability varies directly with the elapsed time between the onset of symptoms and the institution of treatment.

x. *Pes Carus*. I have been rather surprised at the relatively large number of cases of pes cavus seen at our hospital. As a result of the metatarsus equinus with complete obliteration of the metatarsal arch, sustained weight bearing is very uncomfortable. Callosities develop under the metatarsal heads as well as over the dorsal aspect of the toes, which assume hammer position. The majority of cases seen were idiopathic in etiology. One case was due to poliomyelitis and one presented a mild spastic element. Since all of the cases were LOD, no,

EPTI, they were recommended for duty without field service or C.D.D., depending upon the severity of the condition. Those who remained in service received corrective shoes. The majority were separated from the army.

xi. *Fracture of Metatarsals Due to Parachute Jump*. These fractures differ from March fracture in that the site is generally through the distal third of the metatarsal bone at the neck. Usually there are more than one bone involved. In the majority of cases seen at our hospital, the neck of the second, third or fourth metatarsals were fractured. We have had isolated fractures of the fifth metatarsal neck. These fractures roentgenologically resemble the early stage of March fractures which occur in the neck of the metatarsal bone. In the cases of parachute jump, however, one does not see the deposition of excessive callus nor the local bone resorption at the fracture site. This is true even in the cases with displacement of the heads of the metatarsals, where the trauma must have been considerable. In these parachute jump cases, the fracture line remains thin, and bony union occurs with minimal callus formation. This is due to the fact that these patients are hospitalized immediately after their injury and confined to bed. With the discontinuance of weight bearing, subsequent repeated trauma and strain, which are the stimuli for excessive callus formation are avoided.

Painful Heels. These are usually due to spurs or bursitis. This condition has not been commonly met with at our army camp. Spurs are usually located on the inferior medial aspect of the os calcis, at the attachment of the plantar fascia, or on the posterior superior surface. Treatment may be non-operative, when corrective shoes are used to relieve pressure. Operative treatment consists of excision of the spur.

Bursitis is located: (1) Retro-achilleal; adventitious; superficial to achilles tendon; (2) retro-calcaneal; calcaneal; deep

to achilles tendon, and (3) subcalcaneal; overlies spur. Treatment consists of shoe correction, novocaine injection, or excision of bursa.

XII. *Affection of Toes. Hallux Valgus:* The etiology is usually shoe pressure. Properly fitted shoes are essential for relief. If joint changes are present with evidence of hallux rigidus, relief can be obtained by means of a steel insert into the sole extending from the heel to the toe, parallel with the big toe, to prevent motion at the metatarsophalangeal joint. Operative correction has not been carried out at our station.

Overriding 5th Toe: This is not uncommonly seen. Pain is due to shoe pressure. Either shoe correction is essential to relieve pressure, or operative correction must be performed. Freiberg's operation or amputation of the toe may be indicated.

Tenosynovitis: Tenosynovitis involving the achilles, extensor hallucis longus and extensor digitorum longus tendons and sheaths is not uncommon. The treatment is rest and relief from pressure.

There are many other foot conditions which I have seen at our hospital, which will only be briefly mentioned.

One case of thromboangitis obliterans was picked up in an officer who complained of pain in the knee. He was transferred to a General Hospital where the diagnosis was confirmed.

A neurofibroma was excised from the plantar aspect of a foot and the soldier returned to active duty.

Several cases of poliomyelitis have been observed and were recommended for C.D.D. One soldier gave a history of poliomyelitis, yet no clinical evidence of it was found. He developed a marked limp with inversion of the left foot after two months in service. He was ordered to walk normally, and he did, right back to duty.

Another soldier gave a history of poliomyelitis at the age of three years, as well as a history of having been born with a deformed foot. He wore a brace

from the ages of two to nine years and recovered sufficiently to become a truck driver before his induction. He presented a mild metatarsus adductus and obvious voluntary clawing of the toes. His limp was exaggerated, and he required coaxing to move the foot actively through its free range of motion. Muscle power appeared normal and the reflexes were active. The metatarsus adductus was easily correctible. X-rays revealed obliquity of the distal surface of the cuboid and internal cuneiform bones as the cause of the congenital deformity. The shoe was corrected with a raise on the outer border of the sole and a transverse bar was applied. The patient was able to return to duty without field service.

One case presented an abscess of the left foot with low grade osteomyelitis of the internal cuneiform. Incision and drainage was performed with healing, and the patient was returned to duty without field service.

A young soldier had landed on a nail with his left heel about nine years ago. He developed an infection which was drained by incision many times. X-ray revealed irregularity of the posterior aspect of the os calcis. Because of pain and the history of spontaneous drainage every three to four months, a C.D.D. was recommended.

A twenty year old private tripped and injured his left foot as a civilian. He limped with pain ever since. He presented a mild dorsal prominence over the head of the third left metatarsal with mild tenderness. Motion at the metatarsophalangeal joint was free. The roentgenogram revealed broadening, irregularity and flattening of the third metatarsal head with two small osteochondral bodies in the joint. This resembled a Freiberg's infraction. A transverse bar was applied to the shoe and the patient placed on duty without field service.

A nineteen year old private presented an absence of the third and fourth toes of the left foot due to an old gunshot wound.

Symptomatic depression of the metatarsal arch was present. He was given a transverse bar and placed on duty without field service.

A thirty-two year old soldier presented bilateral, severe hallux valgus with bilateral, severe, second hammer toe. Because of his symptoms, a C.D.D. was recommended.

One twenty-five year old soldier revealed severe bilateral pes planus with bilateral hypertrophic osteoarthritis of the astragalo-scaphoid joints. He gave a history of painful feet since childhood. C.D.D. was approved.

COMMENT

From the above, it is evident that there are many foot conditions which can disable a soldier. Many of these are of a minor and temporary nature, but nevertheless as disabling as a serious condition.

Prophylactic measures can avoid some of these temporary disabilities. When they occur, however, immediate and effective treatment is necessary to restore the soldier to active duty status as rapidly as possible. Each case of foot disability will require individual final judgment and disposition in order to comply with W.D. Circular No. 164, pertaining to the use of manpower based on physical capacity. Each enlisted man should be assigned to a position in which he can render the maximum service. The discharge of men who can render effective service is prohibited. On the other hand, the retention of men unable to perform a reasonable day's work for the Army is wasteful.

Acknowledgment is made of some of the illustrations, which were taken from the books of Lt. Col. Philip Lewin and Lt. Col. Alfred R. Shands. The roentgenograms are of cases treated at our hospital.



SURGICAL ASPECTS OF CARCINOMA OF THE STOMACH*

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THIRTY-FIVE cases of carcinoma of the stomach on General Surgical Service "B" from 1929 to 1934 and 114 cases of carcinoma of the stomach on General Surgical Service "A" from 1934 to 1944 are included in this survey. These cases constitute the total number of patients with gastric carcinoma seen by these services during the stated years at the Hospital of the University of Pennsylvania, Philadelphia. There were

TABLE I
SEX INCIDENCE

Sex	No.	Per Cent
Male.....	95	64
Female.....	54	36

ninety-five cases or 64 per cent in males showing the greater incidence in this sex with almost a 2 to 1 ratio. The age incidence showed 81 per cent of the cases between the ages of forty and seventy with the greatest number (34 per cent) between fifty and sixty years of age.

TABLE II
AGE INCIDENCE

Years	No.	Per Cent
20-30	1	0.5
30-40	9	6
40-50	33	22
50-60	51	34
60-70	37	25
70-80	17	12
No age	1	0.5

It was interesting to note the lag between the time the patient first saw a physician and the time the patient reached the surgeon. Unfortunately, the records did

not always contain the data as to when the patient reached the local physician but as a rule this was within a month after the onset of symptoms. Seventy-five per cent of the cases reached the surgeon three months or longer after the onset of symptoms with 42 per cent reaching the

TABLE III
DURATION OF SYMPTOMS BEFORE CONSULTING M.D.

Time	No.
No record.....	101
1 week.....	14
1 month.....	21
2 months.....	4
3 months.....	5
6 months.....	2
1 year.....	2
Over 1 year.....	0

surgeon one year or more after the onset of symptoms. This certainly leaves much to be desired. One hundred thirty-five cases or 91 per cent were able to be explored while 9 per cent were considered inoperable without exploration. Of the group

TABLE IV
DURATION OF SYMPTOMS BEFORE REACHING SURGEON

Time	No.	Per Cent
No record.....	4	3
1 week.....	1	0.5
1 month.....	5	3
2 months.....	29	19.5
3 months.....	22	15
6 months.....	25	17
1 year.....	33	22
Over 1 year.....	30	20

explored only fifty-two patients or 35 per cent were operable. This implies that the surgeon felt he could remove all the lesion and the gastrocolic or gastrohepatic nodes which appeared involved. Of the number resected in this series, fifty-one patients or 34 per cent had a subtotal gastric

* This series is taken from the services of Dr. G. P. Muller and Dr. E. L. Eliason.

resection with gastrojejunostomy. Only one case had a total gastric resection.

In the inoperable cases which were explored, simple gastrojejunostomy was done in twenty-six cases as a palliative procedure and gastrotomy was done in

TABLE V

Cases able to be explored

Operable—42 = 35%

41% = 94%

Inoperable—74 = 60%

Cases not able to be explored

14 = 10%

56% = 66% inoperable

two cases. Fifty-five of the cases explored were so far advanced that no procedure was attempted.

In the overall group, 43 per cent experienced relief of symptoms while 55 per cent

TABLE VI

Procedure Done in Operable Cases

Subtotal resection—41 = 68% = 35%

Total resection—1 = 2% = 1%

35%

did not. The total five-year cures were three or 2 per cent of the total 139 cases in this series. There was no follow-up record in forty-one cases while twenty-six died while still in the hospital following operation. Of these postoperative deaths, twelve of the twenty-six had gastric resection while fourteen had simple ex-

TABLE VII

Procedure Done in Inoperable Cases Which Were Explored:

Gastroenterostomy—26 = 17%

Nothing—55 = 37%

Gastrotomy—3 = 2 = 2%

56%

ploration or gastro-enterostomy. Thirty-nine of the patients lived six months, twenty-six lived one year, thirteen lived two years, and one lived four years. Of the three five-year cures, one is still living after eight years, one is living after fourteen years and one died after eight years due to the carcinoma. The three five-year cures all had a subtotal gastric resection. The one patient in which total

gastric resection was done died post-operatively of pulmonary embolus.

These results are not encouraging. One thing is made clear, however; the patient reached the surgeon entirely too late. Until we know the etiology of carcinoma of the stomach, the only way we can

TABLE VIII

Per Cent Relieved Symptomatically

64 = 43%

No. = 84 = 67%

improve our results is to see that the patients get to the surgeon earlier or that our present form of therapeutic attack is improved. The latter point will be discussed shortly. As can be seen from this series, only 35 per cent of the cases were operable and many of these already had visible spread to the adjacent gastroduodenal and gastrohepatic nodes. The cases in which the pathological condition

TABLE IX
SURVIVAL PERIOD

Time	No.	Per Cent
No record	41	28
P. O. Death	26	18
6 months	39	26
1 year	26	18
2 years	13	9
3 years	0	0
4 years	1	1
5 years	3	2

P. O. Death 12 subtotal resections
14 expl. or enter.

was actually limited to the local lesion as such were nil. Thus before we consider the form of operation offered these patients we realize the surgeon is at a handicap before he starts.

What is the answer to this problem? Is it routine upper gastrointestinal roentgenology just the same as we advise yearly routine chest films? St. John, Swenson and Harvey,⁵ of Columbia University, tried an experiment in the early diagnosis of gastric carcinoma consisting of mass roentgen studies of persons over fifty who had no digestive symptoms of perceptible

significance. Of 2,413 studied, three had unsuspected malignant gastric tumors, an incidence of 1.24 per 1,000. These three underwent subtotal gastric resection. Obviously this study is only in the experimental stage and should be continued for many years to prove its value. It may be one of the answers to the problem.

A more direct answer at present seems to be found in the patients who have gastric symptoms. In the present day of specialization the surgeon can do little actual ground work to aid the cause. The real boost has to come from the general practitioner and gastrointestinal specialists who see these patients first. The time lag between when the patient first sees the doctor and reaches the surgeon is considerable.

Thorstad⁴ reports that over a fifteen-year period from 1928 to 1942 there has been no marked annual increase in the admissions for cancer of the stomach at two of Detroit's large hospitals. He also stated that no evidence has been found to indicate a marked improvement in either the diagnosis or treatment of early carcinoma of the stomach during this fifteen-year period. Earlier diagnosis on the part of the general practitioner and the gastrointestinal specialist and prompt surgery is essential if we are to improve our results in the treatment of carcinoma of the stomach.

Some authors have reported better results in the overall five-year cures in their clinics. Custer⁷ reports 18.75 per cent alive and well for over eight years. If one breaks this figure down, however, it is seen that the series which he reports contained 463 patients. Of these only 141 were operable and of the 141 operated upon only ninety-six were completely followed. It is this total ninety-six that he considers eighteen cases or 18.75 per cent alive and well for over eight years. In terms of the total number of cases in his series, only 3 per cent are alive and well for over eight years. This is only a slightly better percentage than our overall five-year cure rate of 2 per cent.

As for the second line of attack in improving our results, the question of total gastric resection in borderline operable cases is raised. It is known that man can get along almost as well without any stomach as with one-third or one-fourth of it left as shown by the studies of Ingelfinger.⁵ Hence the physiologic aspect of either procedure is justified.

It is just within recent years that the pendulum has swung to the possibility of more widespread use of total gastric resection in borderline operable cases of carcinoma of the stomach.

Lahey and Marshall¹ and Jones and Kehm² have reported two series of total gastrectomy and their results are noted here: Lahey and Marshall¹ report seventy-three cases seen since 1938 with twenty-four postoperative deaths but in the last two years only five deaths occurred in twenty-eight cases. As stated, the procedure was only used in borderline operable cases or in which the lesion was high in the cardia of the stomach. In the majority of cases, total gastrectomy with anastomosis of the jejunum to the esophagus through the abdomen was done provided enough normal esophagus remained. They reported one five-year cure out of the seventy-three cases. The procedure carried a very high mortality with only forty-eight of the patients surviving operation; fifteen lived a year or longer before recurrence caused death; twelve survived one year, seven survived two years and one survived four and one-half years.

The report of Jones and Kehm is a later one and harder to evaluate. However, indications for total gastrectomy by these men were the same as by Lahey and Marshall. Of their eight consecutive cases, however, the patients are all living at present, the postoperative period varying from six to eighteen months.

Naturally, the procedure can be used only in selected cases. Its widespread use would only result in an increased operative mortality in patients with lesions too widespread for surgery, but with its greater

use in selected cases, perhaps we can increase our therapeutic results. Certainly it deserves a trial when our overall five-year cure rate with present means of attack is only 2 per cent.

CONCLUSION

The conclusion to be drawn from the statistics here reported is that cases of carcinoma of the stomach reach the surgeon many months after the onset of symptoms when the lesion is far advanced and inoperable, with the result being that the only thing we have to offer these patients at the present time, namely, gastric resection, was applicable in only 35 per cent of the cases. The inadequacy of partial gastric resection

is also shown when the end result of 2 per cent five-year cures is considered. The possibility of obtaining better therapeutic results with the more widespread use of total gastric resection in borderline operable cases is discussed.

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INDICATIONS FOR DETERMINATION OF THE THICKNESS FOR SPLIT SKIN GRAFTS*

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IT is now a self-evident truism that many of the advantageous properties of a skin graft with certain exceptions provided

embraced while the disadvantageous qualities of each will be minimized. A skin graft cut at a uniform thickness also has obvious

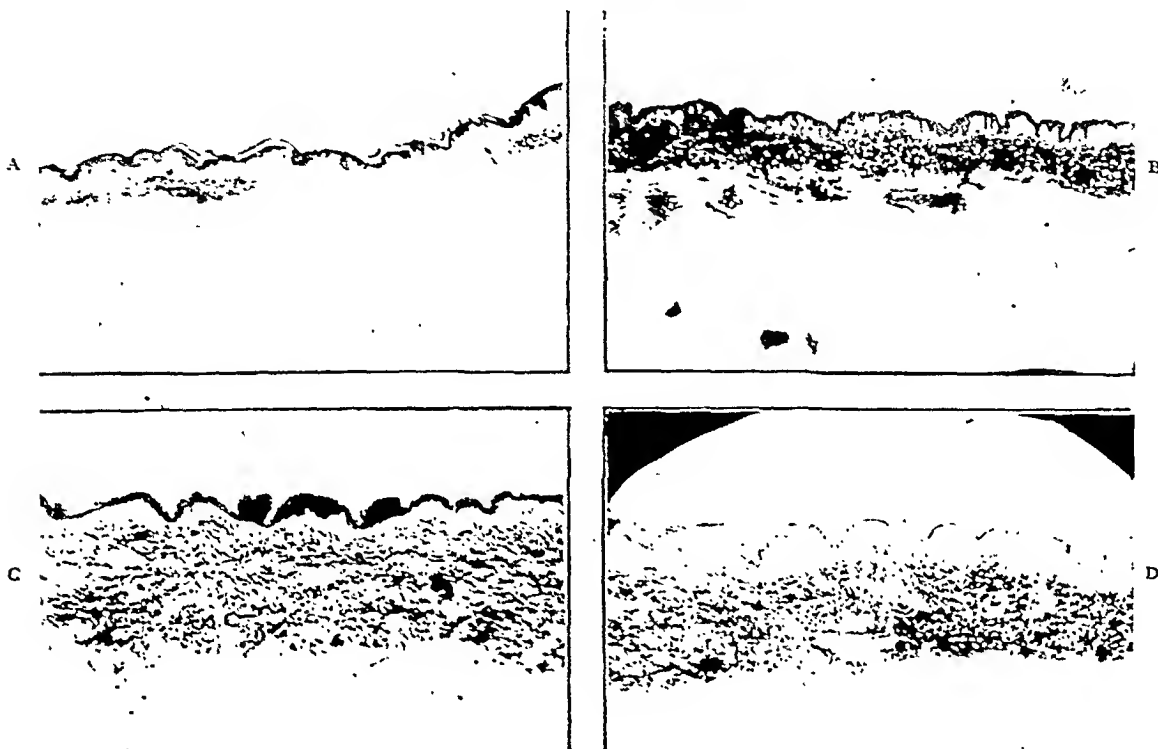


FIG. 1. Sections of thin and moderately thick calibrated skin grafts. X 16. A, male adult graft cut from abdomen about .010 of an inch (.25 mm.) in thickness used to cover a granulating area; a good "take." B, male adult graft cut from abdomen about .012 of an inch (.3 mm.) in thickness used to cover a granulating area; a good "take." C, male adult graft cut from abdomen about .018 to .020 of an inch (.46 to .5 mm.) in thickness. Graft used to cover back of hand on clean raw surface; a perfect "take"; no blistering. D, male adult graft cut from outer thigh used to cover clean raw surface of dorsum and palm of both hands, .014 to .016 of an inch (.36 to .41 mm.) in thickness; a good "take." (From PADGETT. "Skin Grafting." Charles C. Thomas Co.)

a good "take" can be obtained, become maximal the thicker the applied skin graft has been cut on the contrary, as a rule, the disadvantageous properties save that of a certainty of a "take" increase as the skin graft is cut at a more superficial level. This fact suggests the need of attaining in most instances if possible, a skin graft cut at such a level that most of the good qualities of the thin and the thick skin graft will be

advantages. Often because of conditions beyond the control of the surgeon both as to the recipient area and donor site, it is an obvious advantage to a large extent to be able to predetermine the thickness of the skin graft. Another aid, sometimes an almost indispensable one, is to be allowed to use a suitable part of the body for a donor site. When a considerable amount of skin has to be taken, a final advantage is

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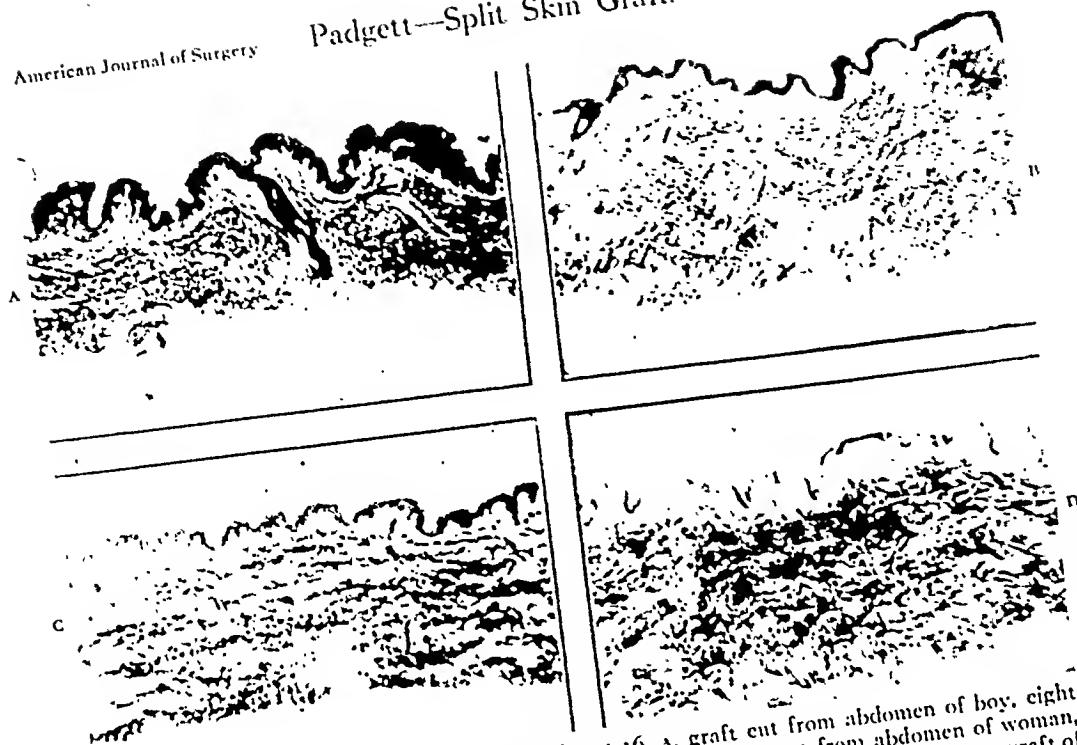


FIG. 2. Sections of thick calibrated skin grafts. $\times 16$. A, graft cut from abdomen of boy, eight years old, about .020 of an inch (.5 mm.) in thickness. B, graft cut from abdomen of woman, age sixty years, pregnant previously; about .025 of an inch (.63 mm.) in thickness. C, graft of male, age fourteen years, cut from abdomen; about .025 of an inch (.63 mm.) in thickness. D, graft of male, age sixty-five years, cut from thigh about .030 of an inch (.76 mm.) in thickness. (From PADGETT, "Skin Grafting." Charles C. Thomas Co.)

for the donor area to be left in such a condition that it is capable of spontaneous regeneration.

To simplify further discussion it might be well to outline a classification of sheet skin grafts:

From a microscopic study of skin grafts, cut by all methods, in my own mind at least, a classification of sheet skin grafts into four types has been evolved: (1) Thiersch (Thiersch's original description of his graft as containing only the epithelial layer probably never was or cannot be cut. There is always some corium: (2) superficial and intermediate "split skin" graft (Blair et al.) one-third to two-thirds of the skin depth; (3) the so-called "three-quarter thickness" skin graft (75 to 90 per cent of the skin depth); and (4) the full thickness skin graft which includes all skin layers.

The following conclusions were reached: (1) The Thiersch graft is cut at a thickness of about .008 of an inch (.2 mm.) to 0.10 of an inch (.25 mm.) in thickness. (2) The

"split graft" or superficial intermediate skin graft as cut with the large knife, in adults is usually from .012 of an inch (.3 mm.) to .016 of an inch (.4 mm.). (3) The "three-quarter thickness" skin graft in adults, which is cut with the dermatome and may be predetermined, is from .018 of an inch (.5 mm.) to .022 of an inch (.6 mm.) in thickness. (4) A full thickness skin graft in an adult, according to our sections, varies in thickness from about .030 of an inch (.88 mm.) to .038 of an inch (1 mm.). (Figs. 1 and 2.)

FACTORS

The following factors have to be considered when one selects the type of skin graft to be used:

Whether the Base Is Granulating or Freshly Denuded. If the base is granulating, it is important whether or not it is almost certainly aseptic or probably not entirely aseptic. When freshly denuded and aseptic it may make some difference

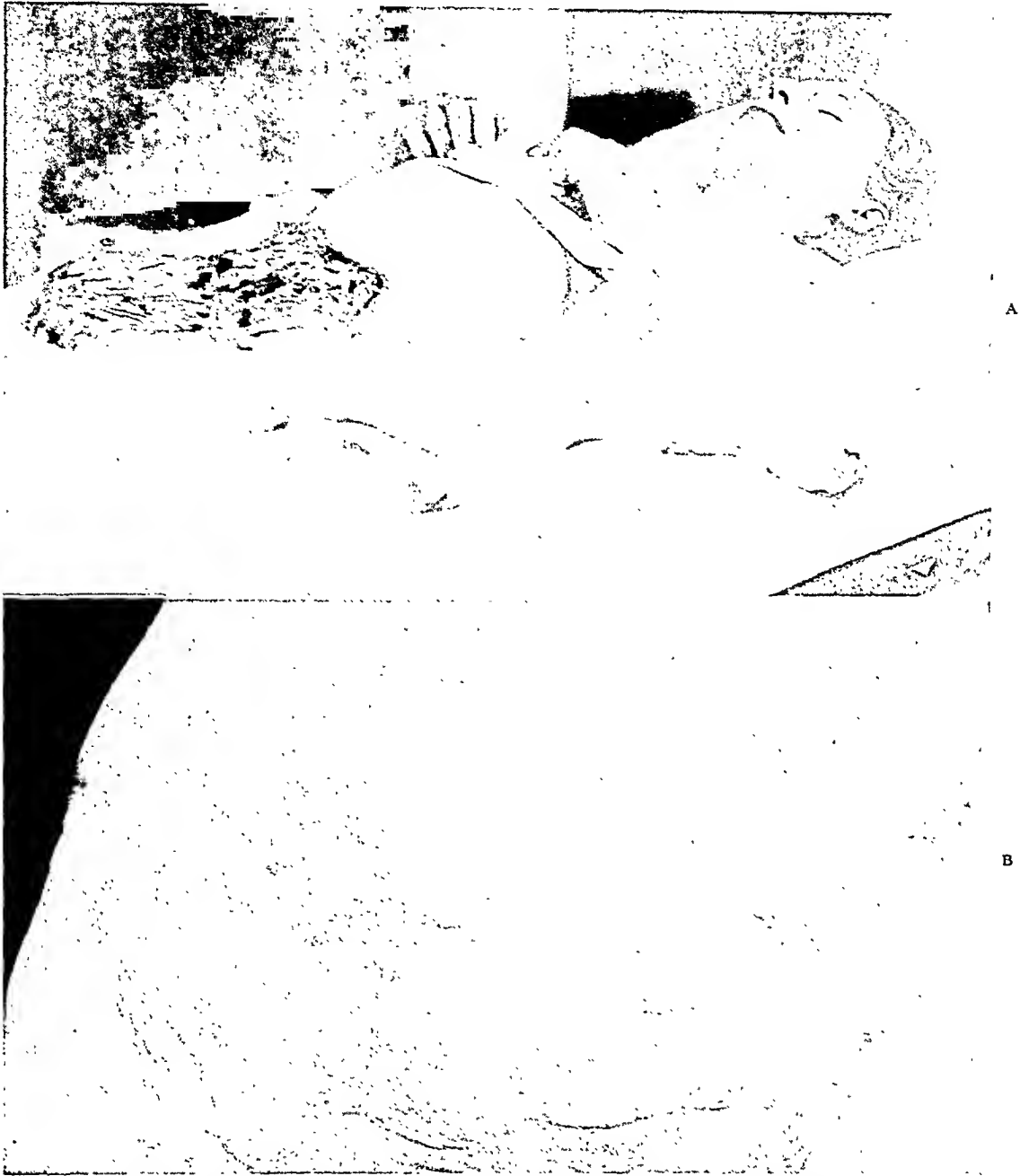


FIG. 3. A, this woman had a large progressively necrotizing ulceration following an abdominal operation. It was eventually stopped after cautery excision. After the whole area was cleaned up with wet dressings the area was covered with a skin graft taken from the thigh and buttocks cut about .010 of an inch in thickness. A good take was obtained. B, the final result after two months.

whether the area is just previously been made surgically or if it is of traumatic origin, as in the latter case the causal factor of the trauma and also the number of hours since the trauma occurred may have some bearing which will influence the selected thickness. (Fig. 3A and B.) One would be inclined to decrease the thickness of the graft somewhat if it were thought that the denuded

area probably would not prove to be an aseptic one, or if sufficient time had intervened for the probability of some beginning multiplication of bacteria. (Fig. 4A and B.)

The Location of the Recipient Area. The location of the recipient area is important. Different thicknesses of skin grafts may be indicated on various parts of the face or when one is relining a cavity the thickness

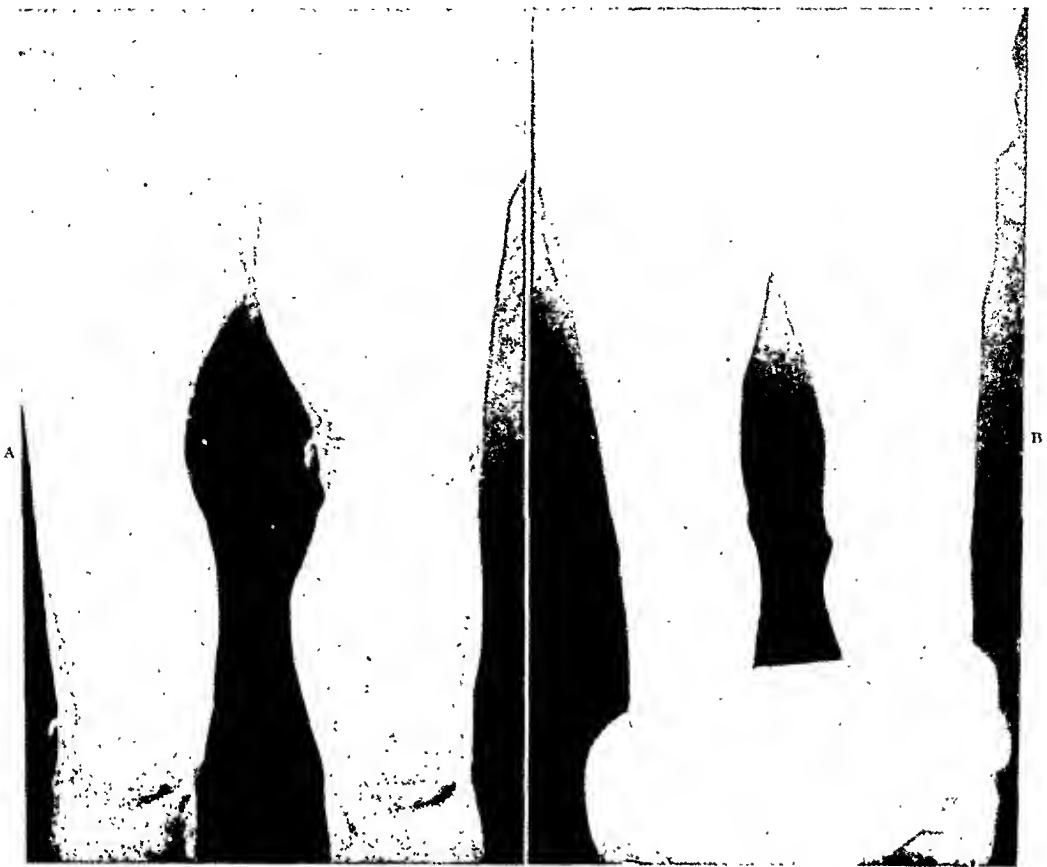


FIG. 4. A, two years before I saw this man he had had large Marjolin's ulcers on both legs excised after he refused amputation which was advised at that time. However, the areas did not entirely heal and beneath the skin was a good deal of deposition of calcium. The scars were completely excised giving a large aseptic denuded base on which were applied large sheets of skin about .020 of an inch in thickness. B, a perfect take was obtained with a good final result.

that one may safely cut a skin graft depends somewhat upon the amount of contamination that one may expect in the bed.

For example, in building a new vagina one has an aseptic field and a relative thick skin graft is advantageous because of minimal contracture while when relining a sulcus in the mouth, because of the relatively unclean bed a thinner skin is the most certain one to "take" and due allowance can be made for subsequent contraction. On the body, legs, arms, hands and feet, when one does not fear a contracture because of the underlying anatomy, and if the condition of the patient is not good, thin coverage only may be the main objective. About joints, the necessity for absence of contracture may lead one to select a graft of considerable thickness when conditions warrant. About the feet, toes, lower

legs, palms of the hands and fingers (Fig. 5A to D), the factor of trauma when conditions are favorable, demand grafts of considerable thickness.

Age of Patient. It is hardly necessary to mention the manner in which the age of a patient influences the thickness of a skin graft which may be obtained. Relatively in a child or baby any sheet skin graft that one cuts will be thinner in comparison with the thickness of the skin than of an adult according to the age of the patient. It is well known that it may be very difficult to cut a skin graft from a baby or a small child, thin enough to leave sufficient epithelial elements in the donor area for regeneration.

Donor Area. The location of the donor area may influence the thickness of skin that may be obtained. The skin of the inner

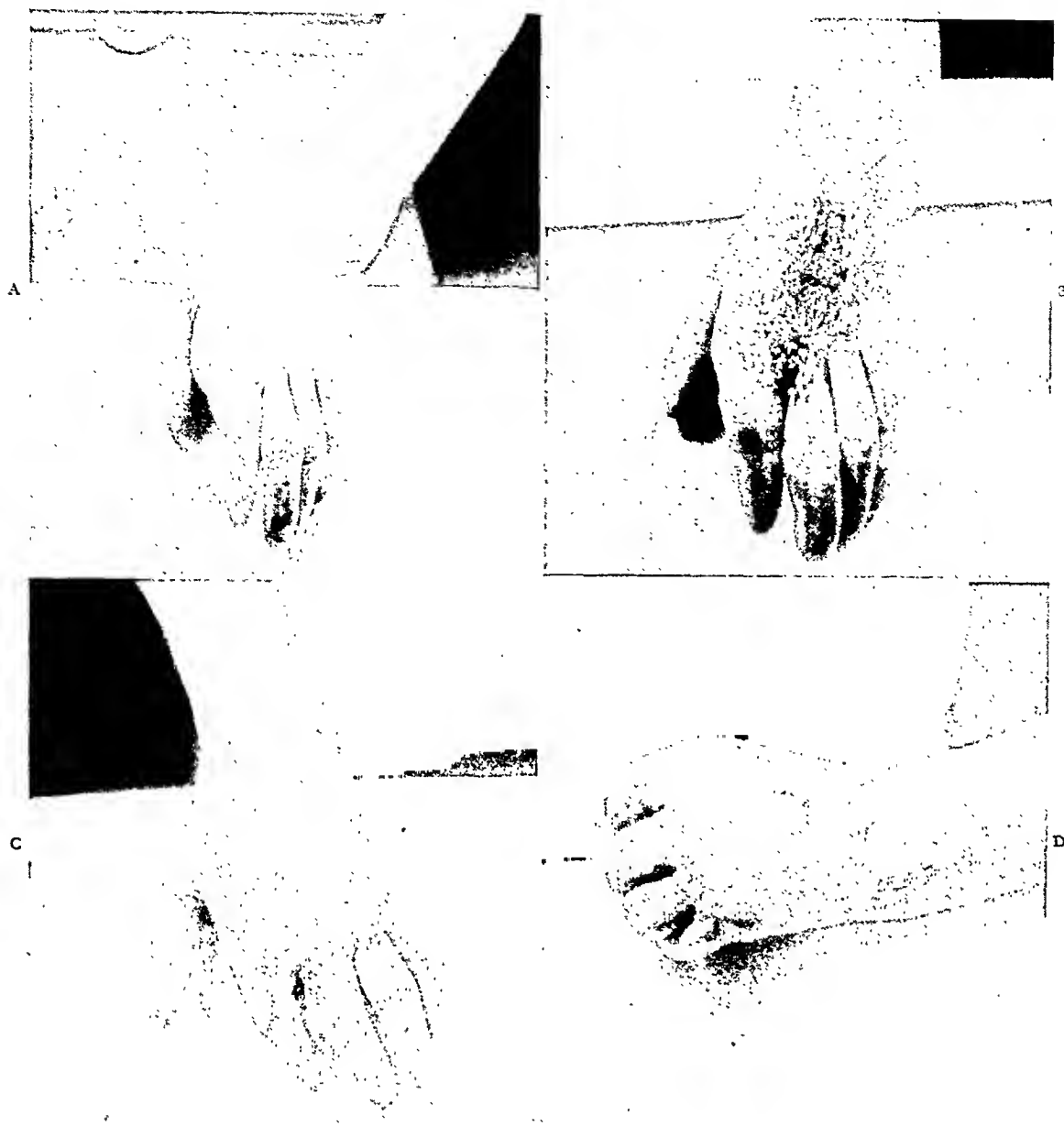


FIG. 5. In this case the ideal thing would have been for the area to have been covered immediately after the mangle burn injury. However, it was neglected for about three months. When she first came to see us her hand was as shown in A. She returned to another surgeon for another operative procedure with the result shown in B. After cleaning up the granulating area it was totally excised down to the tendons and a thick skin graft about .020 of an inch in thickness was placed over the dorsum of the hand with the result shown in C and D. (From PADGETT, "Skin Grafting." Charles C. Thomas Co.)

side of the arm and although less so, the inner side of the thigh may be fairly thin, while that over the outer thigh, abdomen and back especially is thicker. In the female such is especially true. When the female has had multiple pregnancies the skin over the abdomen may be almost paper thin.

One can get a rough idea of the thickness of the skin in an individual by making an incision at right angles with the surface

with a scalpel and then examining the cross-cut skin as to thickness.

Recipient Areas Difficult to Cover with Skin. A skin graft of any thickness is likely not to "take" on fat. This may be a problem when contractures are released, especially about the anterior chest region of fat women. About one-half "take" of a skin graft may be obtained on diploic bones. This in certain instances may allow



FIG. 6. Example of a very large granulating area due to a burn which was covered with a skin graft about .010 of an inch in thickness with a perfect take of the whole area. The function was good without any further skin grafting.

complete healing over the skull. But as a rule, on bone a skin graft will not take in a sufficient amount to be useful. This is absolutely true when a dependent position has to be maintained or trauma withstood. Over tendons unless the uncovered area is very slight, a skin graft of any thickness is usually not indicated. Such conditions usually call for a skin flap.

LESIONS FOR WHICH SKIN GRAFTS ARE PARTICULARLY APPLICABLE

The areas for which skin grafting are advisable fall into two large groups, (1) the granulating more or less superficial relatively non-aseptic areas, whatever their cause may be, and (2) the healed or nearly healed cicatricial contracted lesions due to various causes which when excised or cross-cut provide an aseptic base. To resurface the former, in an adult it is our custom, almost invariably to use a thin

skin graft of about .008 to .10 of an inch in thickness. To resurface and correct the latter with certain exceptions which will be mentioned subsequently, it is our custom to use what we have termed a "three-quarter thickness skin graft." Often the etiology of the granulating areas, the cicatrix or scarred contracture with the exception of one due to excessive irradiation, is not so important as the location. In other words, the principles of the correction often are based upon other factors than that of etiology.

For purposes of illustration it may be well to select certain definite types of lesions which are typical for comment. When a superficial "split" skin graft is used the skin graft is cut with the dermatome or with the large knife by hand, depending upon the size of the area to be covered, the donor area available and which method seems the easiest and the quickest has an influence. In other words, both methods

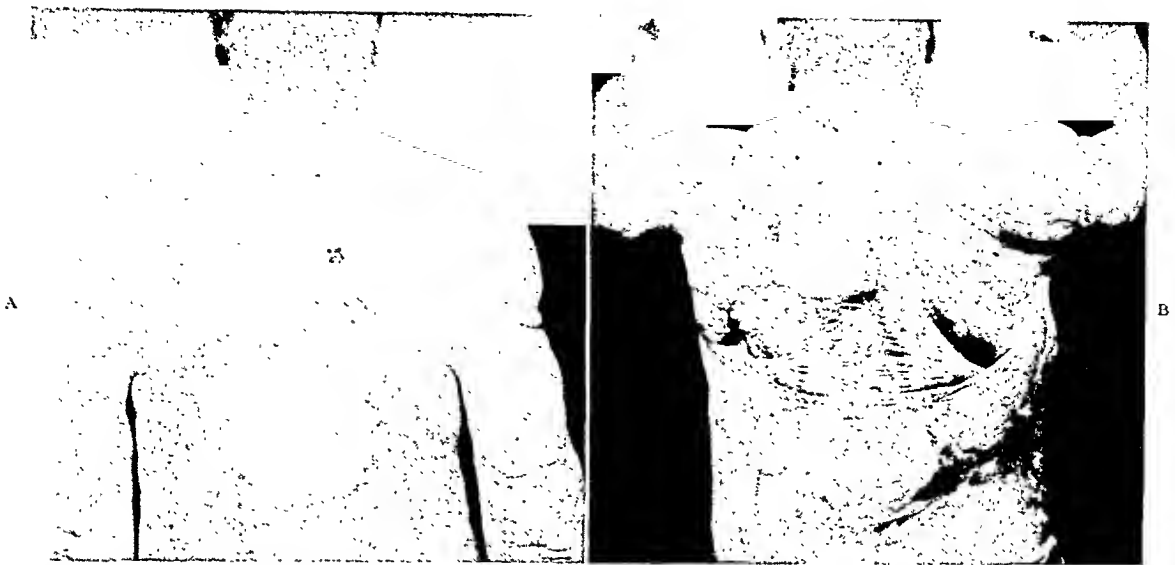


FIG. 7. A, this man sustained a burn on the back when he was a boy. He was unable to raise his arms and he had a very thick scar over the back. The contracture beneath his axilla was released and the scarring was excised from his back to relieve the feeling of tightness and the tendency to ulceration. In this case three-quarter thickness skin grafts about .022 of an inch in thickness were used. B, final result.

are used according to indications for the given lesion and patient.

Skin Grafting in Severe Burns. Following a severe third degree burn the lesions seen by the reconstructive surgeon fall largely into two groups:

In the first group are those individuals presenting a large granulating surface in whom the demand is immediate resurfacing.

In the second group of cases, either the base following the preliminary resurfacing has contracted sufficiently to allow a residual contractual deformity, or else the wound has been allowed to heal intentionally by secondary intention with the idea of relieving the contractual deformity at a later date when one has the advantage of an aseptic field which makes it possible to use a thicker skin graft, as such a graft will contract less and will give a better cosmetic result and better protection.

The Unhealed Lesion. As a general rule, the outstanding demand in the unhealed lesion is to clean up the wound as quickly and as thoroughly as possible so that the granulating area can be resurfaced as early as possible. Although a thin skin graft may not be the ideal material, the surgeon has no choice, as the danger of not obtaining a satisfactory "take" with a thicker skin

graft is too great. A large amount of the tendency to contracture, however, may be prevented by the early resurfacing, and the period of disability with its economic potentialities can be very materially lessened. (Fig. 6A and B.) On the face it is seldom that temporary resurfacing is indicated. However, it often is indicated over the dome of the skull. A thin skin graft gives a poor cosmetic result and as a rule it will have to be removed and replaced by a thick skin graft to effect the maximum final correction. Therefore, as a rule it is just as well to allow the lesion to heal by secondary intention and allow the field to become a relatively aseptic one so that in the correction one can use the skin graft which will be needed finally. The exact opposite applies elsewhere and particularly to the back of the hand where if possible early movement is a desirable goal.

When the granulating base is relatively new, a large thin graft will show a greater tendency to "take" well if the granulation tissue is not interfered with; but when sufficient fibrosis has occurred to give a firm scar base, after the granulation area has been rather widely excised the chances of a complete "take" with a skin graft of a thickness about three-fourths the thickness

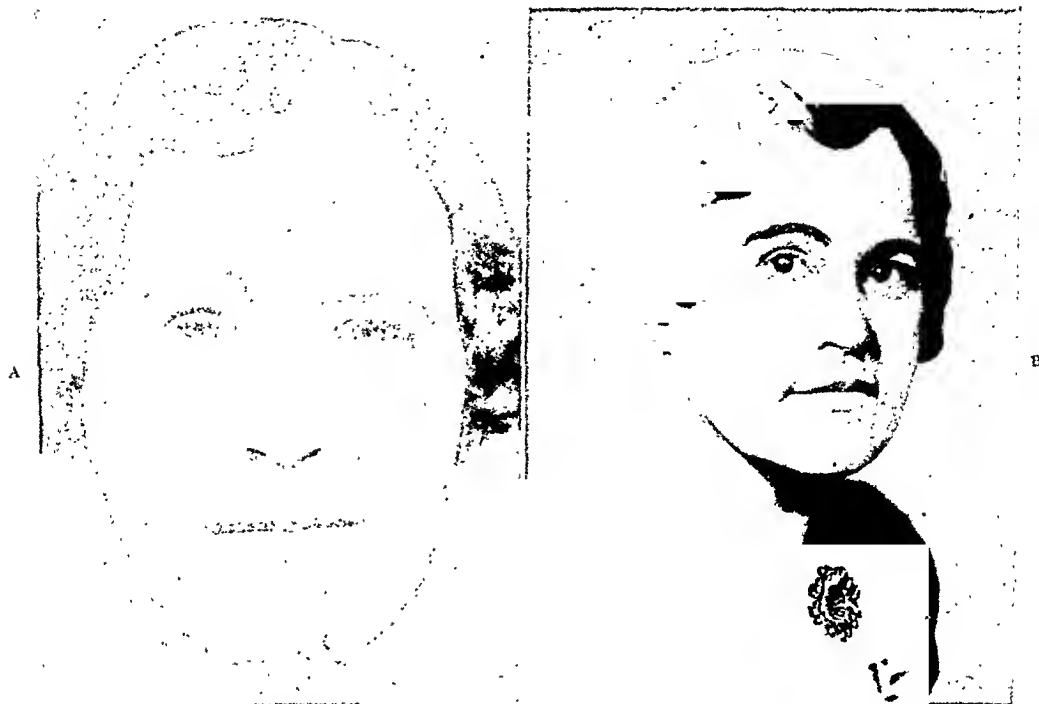


FIG. 8. A, this woman had sustained an injury which had destroyed the right eyebrow and there was a scar extending up on her forehead. A graft was removed from the posterior scalp and all of the fat was removed from the base. Even the lower ends of the hair follicles were cut off with scissors. A skin graft about .020 of an inch in thickness was applied to the forehead. The scalp graft was applied to the eyebrow region. B, final result. (From PADGETT. "Skin Grafting." Charles C. Thomas Co.)

of the skin, are not decreased. Often some of the contracture is relieved and better functional results thereby obtained because of the scar excised and the greater thickness of the skin graft which has been applied.

The Healed Lesion. Formerly when a full thickness skin graft was used to correct a healed defect, one unfortunately had to consider the possibility of a partial or even of a complete failure to obtain a good "take" in about 20 per cent of the operative attempts, dependent principally upon the anatomy of the region.

At the present time, with a few exceptions, for healed or nearly healed lesions the "three-quarter thickness" skin graft is used, one largely eliminates the chances of failure to get a "take." The amount of contracture is minimal and the cosmetic result is good.

When one wishes to correct a contracture about such a region as the axilla, the popliteal space or the elbow, full movement of the extremity is the first consideration. In

the axilla and on the neck it may be found that a good "take" with a skin graft is more difficult to obtain because of the difficulty of obtaining uniform pressure but with proper technic in applying the dressing this factor may be reduced to nearly nil. One can largely ignore this difficulty about the elbow or the popliteal space. To correct a contracture of the neck or axilla after making use of any material available for a switch pedicled flap, the application of a graft of "three-quarter thickness" as a rule, is the method of choice. (Fig. 7A and B.) Also about the elbow and about the popliteal space, the groin, the perineal region, or the back of the hand, the thicker type of graft is preferable. For cicatricial contractures of the palm of the hand and the flexor surfaces of the fingers, the thick skin ("three-quarter" or deep intermediate) graft often offers a good functional result. If one uses a thin graft in these areas it will be found that the final contracture is considerable, that the appearance is not

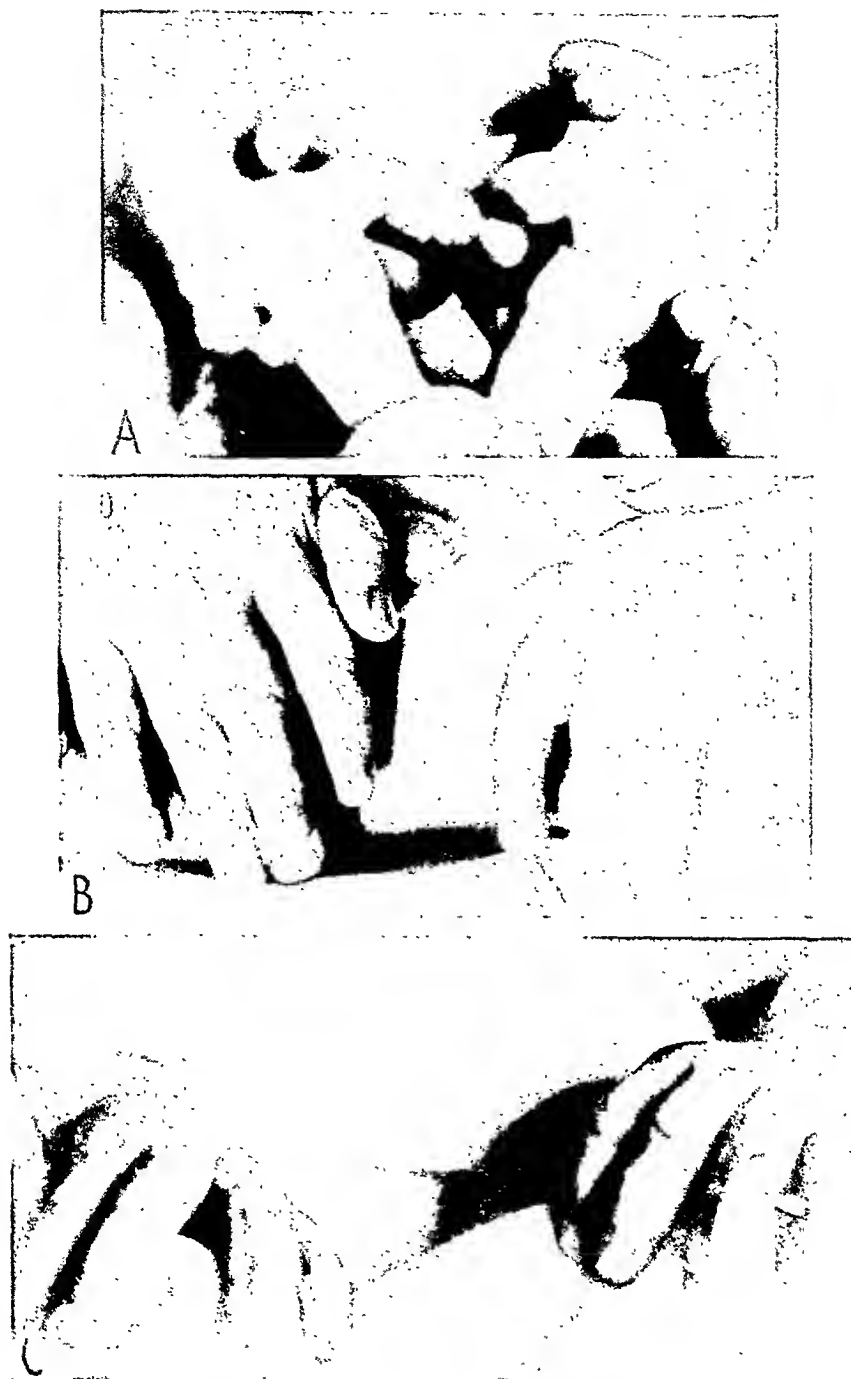


FIG. 9. Example of a full thickness skin graft applied for the correction of web fingers. After a number of years a secondary operation was done to release some scar contracture on the lateral sides of the fingers.

very good, and that in the case of the palm of the hand and the ventral surface of the fingers the protection may not be adequate. On the anterior portion of the neck, a thin skin graft usually contracts from 50 to 70 per cent—too much to correct the contracture—and the appearance usually is not satisfactory. On the neck, the sides of the cheek and over the mandible the deep intermediate or “three-quarter thick-

ness” skin graft should be given preference because it can be cut at a desired thickness and it closely resembles the normal skin in appearance. Some of our most brilliant results have been obtained with large “three-quarter thickness” skin grafts to the neck or face. Probably a full thickness skin graft taken from behind the ear or from the opposite eyelid will most nearly imitate the normal skin when applied over



FIG. 10. A, example of a girl with a large birthmark of the face which has been irradiated. The birthmark was excised and a three-quarter thickness skin graft was applied. B, result one and a half years later. Her appearance is very good with the application of simple cosmetics. (From PADGETT. "Skin Grafting." Charles C. Thomas Co.)

the orbicularis palpebrae muscle for an ectropion of the eye although for large correction, as a rule, insufficient material is available which will give sufficient skin to correct the contracture even if the color of the new graft is not quite ideal. For ectropion of the lips a skin graft of "three-quarter thickness" often is the graft of choice from the standpoint of appearance and function.

When a "three-quarter thickness" deep intermediate skin graft is used on the neck and chin and about the mouth and over the cheek, in some cases a secondary operation is necessary after a period of several months for the purpose of excising the rather heavy scar which tends to form at the juncture of the skin graft with the surrounding normal skin. Moreover, even when the "take" of the "three-quarter thickness" or deep intermediate skin graft is perfect, the possibility has to be considered of having the graft too shiny or in brunettes of presenting a discoloration from pigmentation. Although there is a tendency for the thick skin graft to have a slightly shiny appearance, the grafts that "take" will, without superficial exfoliation, eventually show

almost the normal texture of the skin for the region from which the graft was removed. The grafts in which some superficial exfoliation occurs have more of a tendency to pigmentary changes. In pronounced brunettes pigmentation sometimes occurs after a perfect "take."

Eyebrows. Acceptable eyebrows may be made with a full-thickness skin graft from the scalp. The hair will be found to be somewhat sparse and less plentiful than in a normal scalp, but with care in clipping the new eyebrow may be fairly successful. (Fig. 8A and B.) All the fat and even the deepest of the hair follicles should be removed with the scissors when preparing the graft if one wishes to get a good "take."

Web Fingers. In certain congenital anomalies such as "web" fingers and "web" toes, the application of a full-thickness graft offers the best result especially in children. (Fig. 9A, B and C.) Two operations may be required because there is a tendency for a thick scar to form at the junction of the skin graft and the normal skin. In children, full thickness grafts take well. As one does not need much skin it is usually advisable to cut the necessary

diamond-shaped piece of skin from the abdomen.

Birthmarks. "Birthmarks" of the "port-wine" type in adults, do not respond well to radium therapy. The color is obliterated only in a splotchy manner, and telangiectasis and scaly areas usually form. Often the area, if not actually painful, is at least uncomfortable. When the color is dark, the lesion thick or over-irradiated, it has been our custom to excise those lesions *en toto* after which a "three-quarter thickness" skin graft is applied. As a rule, the scar between the normal skin and the graft will be slightly heavy and will need some excision.

The majority of these skin grafts are slightly whiter than the surrounding skin but they show good texture. In a dark brunette one runs a chance of getting some permanent pigmentary changes in the graft. (Fig. 10A and B.) However, this may not be very noticeable after a period of years. With the aid of some "cover mark," powder or rouge or tattooing (Byars), the appearance of the skin graft can be made to approach normal skin very closely. On the whole, as a rule, the result is extremely satisfactory to the victim of this noticeable deformity.

Cavity Grafting. A skin graft should be thin for relining an eye socket and to get the best socket the stent should be specially made, flattened and oval. One does not need much depth to the socket, but all the diameter possible is necessary. For deepening an obliterated gingivolabial sulcus or to release a scar band in the mouth, nostril or pharynx, a comparatively thin skin graft is preferable and one should not fail to remember that about two-thirds more lining should be applied than will be needed eventually to correct the lesion.

Artificial Vagina. One of the most striking uses of the "three-quarter thickness" skin graft is the formation of an artificial vagina. There has been some published work which would indicate that an artificial vagina might be formed by inserting a

bare stent in the space between the rectum and the bladder. I cannot believe that such a procedure can be successful in reforming a vagina unless some remnants of vaginal mucosa are present. The formation of an artificial vagina by means of a "three-quarter thickness" skin graft is an easy procedure. It gives satisfactory result and is not dangerous.

Urethra. McIndoe has successfully reconstructed an acceptable urethra for a hypospadias. But in my experience an operation which employs skin flaps is the better operation for most cases of hypospadias. A skin graft urethra contracts and gives a chordee in erection while if proper correction of the chordee is made previous to the transplantation of a skin flap erection will occur without ventral bending.

SUMMARY

To summarize, as a rule, in adults thin skin grafts of from .008 to .010 of an inch in thickness are used to cover granulating areas and to reline cavities such as the eye sockets and sulci in the mouth. "Three-quarter thickness" skin grafts cut from .018 to .022 of an inch in thickness in adults but thinner according to the age of the child, are used after release of healed or nearly healed contractures and to cover most aseptic denuded areas or cavities. Similarly, the "three-quarter thickness" skin graft is used on the neck and face. It will give the maximum cosmetic correction as a rule and insofar as skin grafts are concerned in contradistinction to skin flaps, the minimum contracture if due allowance for contracture is made. In children full thickness skin grafts are used when small areas are to be covered and in web fingers. For the lower eyelid when a small ectropion is present, a "full thickness" skin graft from behind the ear may be acceptable. When a large healed ectropion of the eyelid or lip is to be corrected a non-hairy down area is selected such as the inner side of the arm where sufficient skin may be obtained.

REFRIGERATION IN SURGERY

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THE use of refrigeration in surgery dates back only a relatively few years.

In 1941, after several years of animal experimentation, Allen showed clinically that a tourniquet could be applied to a limb and the part distal enveloped in ice to produce adequate surgical anesthesia.¹ This method was particularly applicable to patients who were poor risks suffering from gangrene. In this and the studies that followed refrigeration was postulated to do four things: first, to produce anesthesia; second, to increase the survival time of anemic tissue; third, to control infection; and fourth, to prevent and control shock. Of these postulates only the first has been proven. The clinical studies, as a group, have not been well controlled except for those dealing in reduction of mortality in patients who have had an amputation for gangrene. The experimental studies are better controlled but in many cases have been equivocal.

The experimental evidence may be divided into five subsections. These will be discussed first. The clinical evidence is of a more conglomerate nature and will be presented later.

GENERAL EFFECT OF REFRIGERATION ON TISSUES

The velocity of most biologic reactions varies directly with the temperature. Cellular activity stops at a temperature close to freezing. Conduction in a nerve trunk in warm blooded animals stops between 25° and 30°C.² This accounts for the phenomenon of refrigeration anesthesia.

Cooled tissues become anesthetic and their metabolic rate lowered. After exposure to a temperature of 3° to 4°C. for twenty-four to ninety-six hours, the tails of rats show marked degeneration of nerves and muscles in the cooled areas.³ Low tem-

peratures produce cellular injury by direct effect and by ischemia of the cooled part. The vasoconstriction concomitant with cold results in a lack of oxygen and it is generally agreed that this causes most of the damage. During cooling, there is said to be an accumulation of tissue metabolites which cause reactive hyperemia after the cooling agent is removed.²

SURVIVAL OF TISSUES

In his early work, Allen investigated the survival time of extremities subjected to complete asphyxia.⁴⁻⁶ The ligated leg of a rat survived thirteen hours and that of a dog fifteen hours. The main complication was secondary shock on release of the tourniquet. Allen noted that even slight elevations of the body temperature multiplied enormously the effects of mass ligation. Gangrene occurred earlier and secondary shock on release of the tourniquet was proportionately greater. Reducing the temperature of the ligated part decreased the danger of gangrene and secondary shock. He believed that the best temperature for an asphyxiated limb was 2°C.

Brooks and Duncan⁹⁻¹¹ studied the effects of temperature on the survival time of anemic tissues. Rats' tails were subjected to a pressure of 130 mm. Hg. at temperatures ranging from -5°C. to 40°C. The time for gangrene to develop was recorded. Between 1° and 5°C. the tails would survive over ninety-six hours; at room temperatures they would survive eighteen hours of pressure; and at 40°C. they would survive only three to four hours. Pathologic studies revealed that although gross survival was present, microscopically there was marked fibrous replacement of the muscular and nervous tissues. In another experiment the tails of two rats were subjected to a pres-

sure of 130 mm. Hg. at 30°C. for sixteen hours. This time period invariably resulted in gangrene. One animal was then subjected to a temperature of 40°C. Gangrene began in two hours and was complete in twelve. In the other the tail was kept at 1°C. The tail looked normal in twenty-four hours, but twenty-four hours after it was allowed to return to room temperature gangrene was present. In short, refrigeration increased the life of anemic tissues. This was at the expense of degenerative and fibrotic changes which may have been due to the cold or to the anemia.

CONTROL OF INFECTION

Allen injected rat feces into the legs of cats and dogs.¹² Refrigeration for two to five hours with a tourniquet in place had no effect on the infection. If the extremity were kept in ice for twenty-four to forty-eight hours, there was improvement while the tourniquet was in place but gangrene soon followed its release and the animals died. Also, pure cultures of streptococci were injected into the legs of rabbits. Refrigeration with a tourniquet held the infection down until after release of the tourniquet but ultimately was of no value.

Brooks and Duncan¹¹ introduced oil of turpentine and cultures of *Staphylococcus aureus* into the skin of the back of anesthetized dogs. If the wound temperature were kept at 40°C., there was marked inflammatory reaction in twenty-four hours and central necrosis in forty-eight. Controls at 37°C. showed slightly less reaction. At 10°C. there was only slight inflammation after forty-eight hours. In this last group the part was allowed to warm. By ninety-six hours the lesions resembled the control group at twenty-four hours. Thereafter the lesions which had been initially cooled had larger necrotic centers than the control group.

Bruneau and Heinbecker¹³ inoculated suspensions of hemolytic streptococci into the subcutaneous tissues and joints of dogs' legs. In some animals the limb was immersed in cold water at a constant tem-

perature of 6°C. while controls were kept at room temperature. The inflammatory response seen in the control animals was absent in the cooled tissues. At room temperature the decrease in the number of bacteria followed a logarithmic curve whereas no significant decrease occurred in the chilled limbs. The authors believed that cooling delayed the rate of destruction of bacteria in spite of the inhibition of bacterial growth which takes place at low temperatures.

CONTROL OF SHOCK

Blalock and Mason produced shock due to hemorrhage by removing 3 per cent of the body weight (one-third of the blood volume) from the femoral artery over a thirty-minute period.¹⁴ Of fourteen controls, five recovered, the average duration of life in the remaining nine being about three and one-half hours. In nine animals whose temperature was raised 3.7°C. the average duration of life was five and one-half hours and all died. In eight animals chilled to lower the rectal temperature to 12.3°C. the average duration of life was eleven and one-half hours and all these also died. In this experiment the application of cold did not increase the chance of survival but did double the survival time. Similarly blood was removed from dogs until the shock level of blood pressure was reached (75 mm. Hg.). Eight animals were heated to raise the body temperature 3.6°C. and fifteen cooled to an average of 6.6°C. Those exposed to cold lived twice as long and one of the refrigerated animals survived.

Duncan and Blalock¹⁵ demonstrated that freezing during a crushing period protected the animals considerably from shock and local fluid loss. The metabolism of the tissues was reduced and less injury resulted from the inadequate blood supply. Refrigeration after crushing had little or no influence.

EFFECT OF COOLING ON WOUND HEALING

Large and Heinbecker¹⁶ produced clean wounds in dogs' legs. The extremities were

then kept either at room or cooled temperatures. During the healing phase biopsies were taken and tensile strengths measured. They found that during the cooling period there is no cellular response to the trauma of the incision. At any given period during the healing process the cooled incisions showed delayed healing as evidenced by decreased tensile strength. The degree of delay in healing was roughly proportional to the duration of the cooling period. Cooling a limb for forty-eight hours was shown to result in sufficient tissue damage to cause a marked effect on wound healing for more than two weeks. In addition it was found that prolonged refrigeration (seventy-two hours) followed by delayed suture resulted in a higher incidence of infection than would have been the case if cooling had not been used.

CLINICAL EVIDENCE

The first clinical report appeared in 1941.¹⁷ Fifty-seven amputations were performed on forty-five patients suffering from gangrene. There was an overall mortality of 15.5 per cent. Crossman et al. stated that the anesthesia was adequate, that necrosis was limited and that infection was stemmed. They believed that refrigeration did not weaken the barriers to infection, did not reduce the local vitality of tissues and did not create the additional dangers of thrombosis and embolism.

McElvenny in the same year¹⁸ said that patients undergoing amputation under refrigeration anesthesia have no pain and do not need additional anesthesia. The operation is practically bloodless, shock is greatly diminished, the mortality rate is lower and the results are as satisfactory as by any other method. Two of the case histories presented are significant. One was that of a man who sustained a crushing injury with traumatic amputation of both legs at the knees. He was in profound shock. The stumps were packed in ice for fifty-eight hours while he was treated for shock and pneumonia and prepared for surgery. Secondary amputation was done

under ethylene anesthesia. The stumps were cold and firm, the muscles red and healthy and blood clots absent. Primary healing took place. There was pain in the stumps prior to cooling but none after. The second patient was a seventy-eight-year old man with wet gangrene of the lower extremity. His leg was kept in ice for twenty-eight days. No tourniquet was used. There was no gross damage to the skin and there was no pain. A tourniquet was applied and a mid-thigh amputation performed. Recovery was uneventful. McElvenny thought that cooling without a tourniquet was bacteriostatic, prevented toxic absorption and alleviated pain.

O'Neil¹⁹ reported the experiences at the Boston City Hospital. From 1930 to 1939, there were 162 cases of major gangrene deemed inoperable. The mortality rate of these patients was 100 per cent. The mortality rate of 270 patients with major gangrene subjected to amputation was 53 per cent. From 1940 to 1943, fifty-four patients were prepared with refrigeration; four died before operation. Of the fifty operated patients sixteen died, a mortality rate of 32 per cent. There was then a 21 per cent reduction in deaths. O'Neil stated, "The immediate salutary effect of chilling of tissues on the more prominent signs and symptoms was most striking. Relief of pain was observed in every case and without the aid of the customary medication. It is well known that sudden arterial occlusions, as from an embolism, are most painful and that great discomfort persists for many hours. . . In this group the relief of pain has been most dramatic. . . Shock was practically absent in fifty cases. The progress of gangrene and sepsis was notably inhibited." One of his patients was a ten year old boy in whom gas gangrene of the upper extremity, axilla and chest wall appeared after a compound fracture of both bones of the forearm. When the boy was in extremis a tourniquet was applied to the upper arm and the extremity packed in ice. His condition improved remarkably. Am-

putation was performed twenty-two hours after onset of refrigeration. Convalescence was uneventful. On the other hand, two of the patients died of gas gangrene which developed in the stump.

Richards²⁰ was the first to present case histories with pathologic studies. His first patient was a fifty-two year old woman with an embolus to the lower extremity. Papaverine, lumbar sympathetic block and femoral artery exploration did not result in improved circulation. On the third postoperative day a line of demarcation could be felt. On the fifth postoperative day the limb was refrigerated and refrigeration continued for two weeks. The limb did not become grossly viable and a low thigh amputation was performed. Grossly, the limb was gangrenous but infection and necrosis were minimal. Microscopically, the muscles showed marked degeneration. The small vessels contained very few cells. The nervous tissue showed mild degenerative changes and there was necrosis of the dermis. The second patient was a seventy-year old man with painful ulcers of the foot due to arterial insufficiency. A tourniquet was applied, the limb refrigerated for two and a half hours and superficial nerve section performed. The leg was allowed to return to room temperature over four days. Leg pain reappeared, the toes looked as though they were about to become gangrenous and mid-thigh amputation was performed. Degenerative changes were again seen in sections of nerve and muscle.

A brief review of the literature reveals five other clinical applications of refrigeration. It has been used as a temporizing measure in acute vascular occlusions and in traumatic arterial spasm. Cold has been tried in infections in the presence of an inadequate blood supply. O'Neil¹⁹ described a young man with scleroderma and a deep infection of the palmar fascial spaces. Heat resulted in rapid spread of sepsis with bleb formation. Packing the forearm and hand in ice resulted in gradual recovery. Webster, Woolhouse and Johns-

ton²¹ noted tremendous tissue reaction when patients with immersion foot were exposed to room temperatures. There was edema, ecchymosis and bleb formation suggestive of the reaction of feet with impaired blood supply that are developing gangrene. Reduction of temperature by the application of icebags was the single best therapeutic measure at the time. O'Neil²⁰ has refrigerated the lower extremity of several patients with deep venous thrombosis. In a small series so treated none needed femoral vein ligation. Mock²² used refrigeration anesthesia in twenty-seven patients for the cutting of small split thickness grafts.

TECHNIC

The method is essentially one of combined ligation and refrigeration. The tissues are refrigerated, not frozen. If the tissues be cooled a little below 0°C., freezing takes place with irreversible cellular changes. A skin temperature maintained between 8° and 10°C. is most desirable. When the skin is kept at 8°C., the muscles are usually 9°C. and the bone 10°C.

The application of the tourniquet itself is very important. Rubber tubing 10 to 12 mm. in diameter is the best material for ligation. Allen showed¹² that wide bands such as Esmarch bandages, by traumatizing wide masses of tissue, contribute to a greater degree of secondary shock and injure nerves more than do narrow bands. The site for the tourniquet is surrounded with ice bags for fifteen to twenty minutes prior to application. This minimizes discomfort. Two turns of the tourniquet are made at the chosen site as tightly as possible. Care is taken not to pinch the skin. For a low thigh amputation the tourniquet is applied at the junction of the upper and middle thirds of the thigh. Other sites are chosen as the dictates of the case demand.

The extremity is packed in shaved ice up to and including the site of the tourniquet. The whole is encased in rubber sheets or in a box. Precautions should be taken to

allow drainage of water. The ice should be checked to see that the anterior parts of the extremity remain covered. Skin temperatures may be checked with an ordinary laboratory thermometer.

In the average patient it takes two and a half to three hours of icing to allow a painless amputation. In thin limbs this time is decreased and in fat limbs increased. There is no especial need for hurry. The tourniquet and ice may remain in place for twelve hours and even more without change during operation and in healing.

Morphine is seldom if ever needed. Thirty cc. of whiskey is excellent for the patient both pre- and postoperatively.

When the desired anesthesia has been obtained and when the patient is in condition for operation, he is brought to the operating room with the limb still packed in ice. The ice is not removed until the operating team is ready to make the incision. The limb is taken out of ice and the skin prepared. For the usual elderly patient a circular incision is made at the level of the upper border of the patella and the muscle and bone layers staggered. The large vessels are tied (both absorbable and non-absorbable suture material has been used) and the tourniquet released. Other bleeding points are then caught. Closure is simple; the deep fascia is approximated with interrupted sutures and the skin closed similarly. No drains are used. If these be needed, the stump is left open instead. Skin traction is always used when the stump is left open and frequently when it is not.

After the tourniquet is removed, the circulation is seen to return promptly. No thrombosis is apparent. The blood appears normal. The muscles are somewhat brighter in appearance than usual.

Essentially the same technic is used in lower level amputations and in amputations of the upper extremity.

The operation is without pain and without shock. Pulse and blood pressure levels remain constant. Postoperative nausea, vomiting and pain are not experienced.

The stump is packed in ice bags and the temperature gradually allowed to return to normal. Ordinarily ice bags are kept on for two days. The patient is allowed out of bed on the first postoperative day.

Most wounds heal by first intention. "The percentage of first intention healings is comparable to that after similar operations done under other anesthetics."¹⁹ Incisions in refrigerated foci heal more slowly than in non-refrigerated places. Hence the skin sutures are kept in for fifteen to twenty days.

The "dog ear" protrusions at each side of the stump gradually retract. A comfortable stump is obtained and one that will well bear a prosthesis. If traction is not used postoperatively the end of the femur in a small number of cases will gradually become subcutaneous at the lateral aspect of the stump.

CONCLUSIONS

As in many problems in medicine there is a discrepancy between what was postulated, what was found in animal experimentation and what was found in actual practice. The problems of the original postulates remain unsolved, except for the actual production of anesthesia. The chief difficulty is in the dearth of well controlled clinical studies.

The question whether refrigeration prolongs the survival time of anemic tissue remains unanswered. The evidence tends to show that it does. The blessing is not unmixed because of the fibrous replacement of nervous and muscular tissue. The only clinical report with pathologic studies (Richards²⁰) is equivocal because arterial insufficiency was established before refrigeration was applied.

The bacteriostatic action of cold *in vivo* is on a weak footing. In all the experimental studies cold was of no value. Clinically, it was. O'Neil's demonstration¹⁹ of the value of cold in a palmar infection in a patient with scleroderma and in a case of gas gangrene and on the other hand the appearance after refrigeration of gas gangrene in

the stumps of two refrigerated limbs merely outlines the ramifications of the problem.

The published case histories¹⁷⁻¹⁹ praise the value of cold in shock. Blalock's studies tend to confirm this although his results are not conclusive.

In the elderly, toxic patient with gangrene and sepsis, amputation with a tourniquet and refrigeration gives excellent results. Here is the chief indication for refrigeration amputation. Pain and shock are eliminated and the operation is performed in a bloodless field. Even then one might wonder whether the tourniquet is not the chief reason for this. If such a patient had a tourniquet applied and received general treatment without refrigeration, when amputation were performed would the results be comparable? The work of Adolph²³ among injured Chinese soldiers suggests that they would be. To those who have seen amputations performed under ice and tourniquet this is unlikely because there is yet no other single method for combating shock, holding infection in abeyance and producing anesthesia.

SUMMARY

The experimental and clinical evidence for the value of refrigeration in lengthening survival time of anemic tissue, controlling infection and preventing shock has been outlined. A technic for refrigeration amputation is presented. Final conclusions can not be drawn and must await more detailed and controlled studies.

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SOURCE OF NERVE AUTOGRAFTS IN CLINICAL SURGERY*

TECHNIC FOR THEIR SUTURE

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THERE is ample evidence to show that the most favorable type of graft for the repair of a nerve defect is the autograft. It is true that in the experimental animal good functional recovery may occur following the use of homografts that are fresh, stored in saline solution, Ringer's solution⁹ or serum, or even fixed in formalin.¹³ But the incidence of failure of such grafts is too great to risk their use in man.^{10,12} Satisfactory results have been reported with dehydrated nerve grafts in the experimental animal¹⁴ but results obtained from their clinical use have not yet been published.

There is no doubt that autografts are more successful in the experimental animal than homografts.¹³ Moreover, there is some indication from our experimental work that cable grafts are superior to single thick grafts for the repair of defects in large nerves. The strands of the former are more readily vascularized and necrosis within the graft is less apt to occur. As a matter of fact, single autografts could not be used for the repair of defects in the major nerves in man inasmuch as there is no justification for sacrificing one major nerve for another unless there existed the unusual circumstance in which the nerve to be employed as the graft were from an amputation stump or otherwise of little or no use to the patient. The use of autografts presents two important advantages over homografts. First, one would thereby avoid blood group incompatibility, a possible factor in accounting for the necrosis of homografts. Second, one would eliminate acquired active immunity of host to homograft tissue which may be responsible for the dismal results obtained with nerve

homografts just as it seems to explain the destruction of skin homografts.³

Davis, Perret and Carroll¹ have expressed the opinion that cable grafts, in which thin nerves are used to form a cable the caliber of the nerve to be repaired, are "doomed to failure because of the technical difficulties of suture." It is true that the use of any form of thread (silk, wire, etc.) for the purpose of suturing a cable graft results in considerable damage to the strands of the graft and, all in all, very unsatisfactory unions. However, the recent introduction of plasma clot for the purpose of forming and suturing a cable graft¹³ makes it possible to circumvent these "technical difficulties of suture" and places the use of cable grafts on the agenda of the day. Davis and his associates consider that "it is the homogenous type of graft which is most applicable in Army general hospitals which are amputation as well as neurosurgical centers." However, experimental and clinical experience weighs heavily against this recommendation.

Granted then that the autograft alone should be employed the question arises as to which nerves should be sacrificed for use as grafts. It has been demonstrated that functional efficiency after regeneration of nerves depends to some extent upon the fibers attaining a size which approximates their normal diameters.⁷ If the size of the Schwannian tubes of the nerve graft strictly limits the caliber of the downgrowing axis cylinder, one might conclude that grafts taken from sensory nerves would be unsuitable for the repair of motor nerves since they contain fewer large nerve fibers and Schwannian tubes than the latter. (Figs. 1 and 2.) It is known, for

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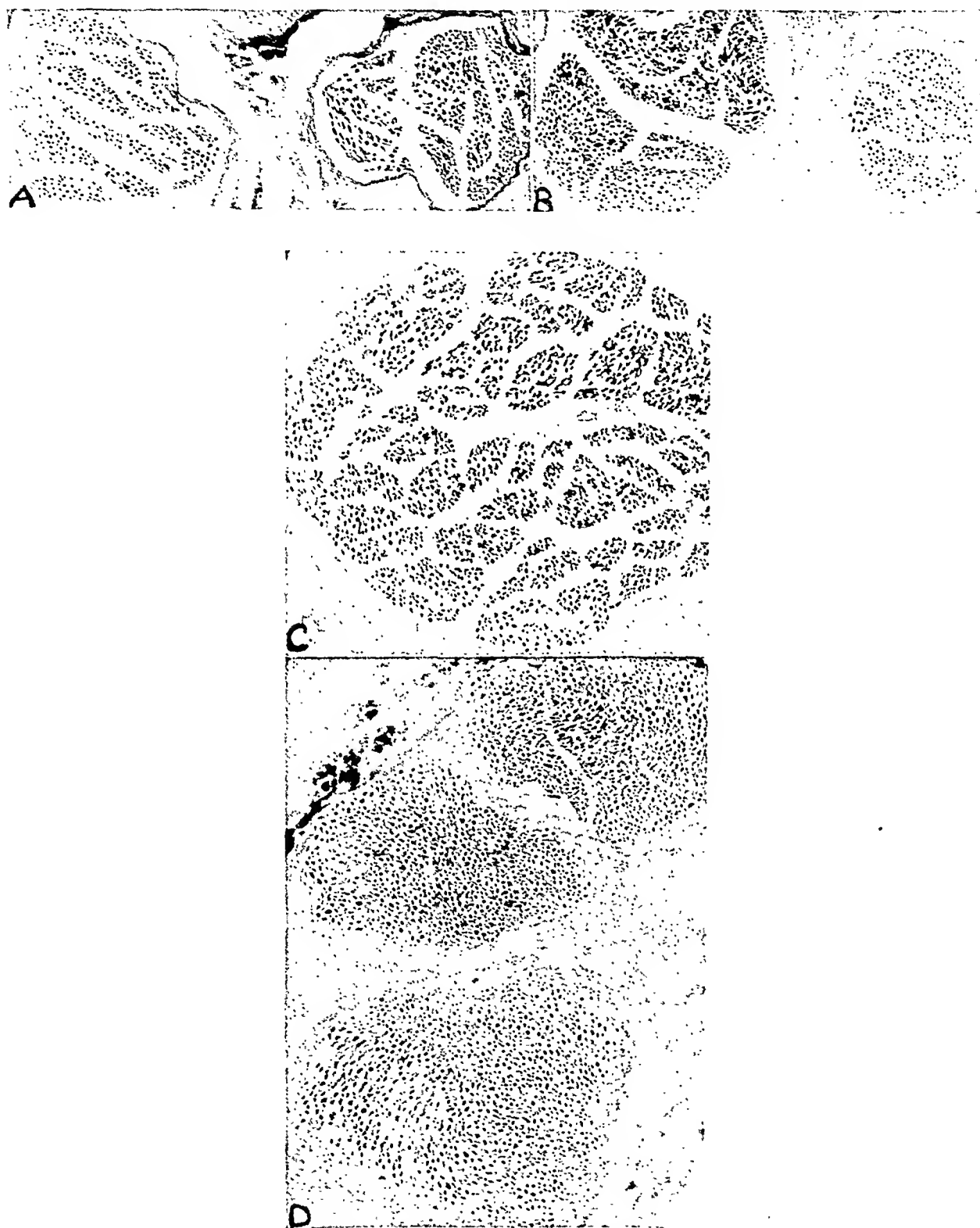


FIG. 1. Gros-Bielschowski preparations showing axis cylinders of medial (A) and lateral (B) antibrachial and lateral femoral (C) cutaneous and intercostal (D) nerves. The intercostal nerve contains a somewhat greater number of large axis cylinders but the difference is not very marked.

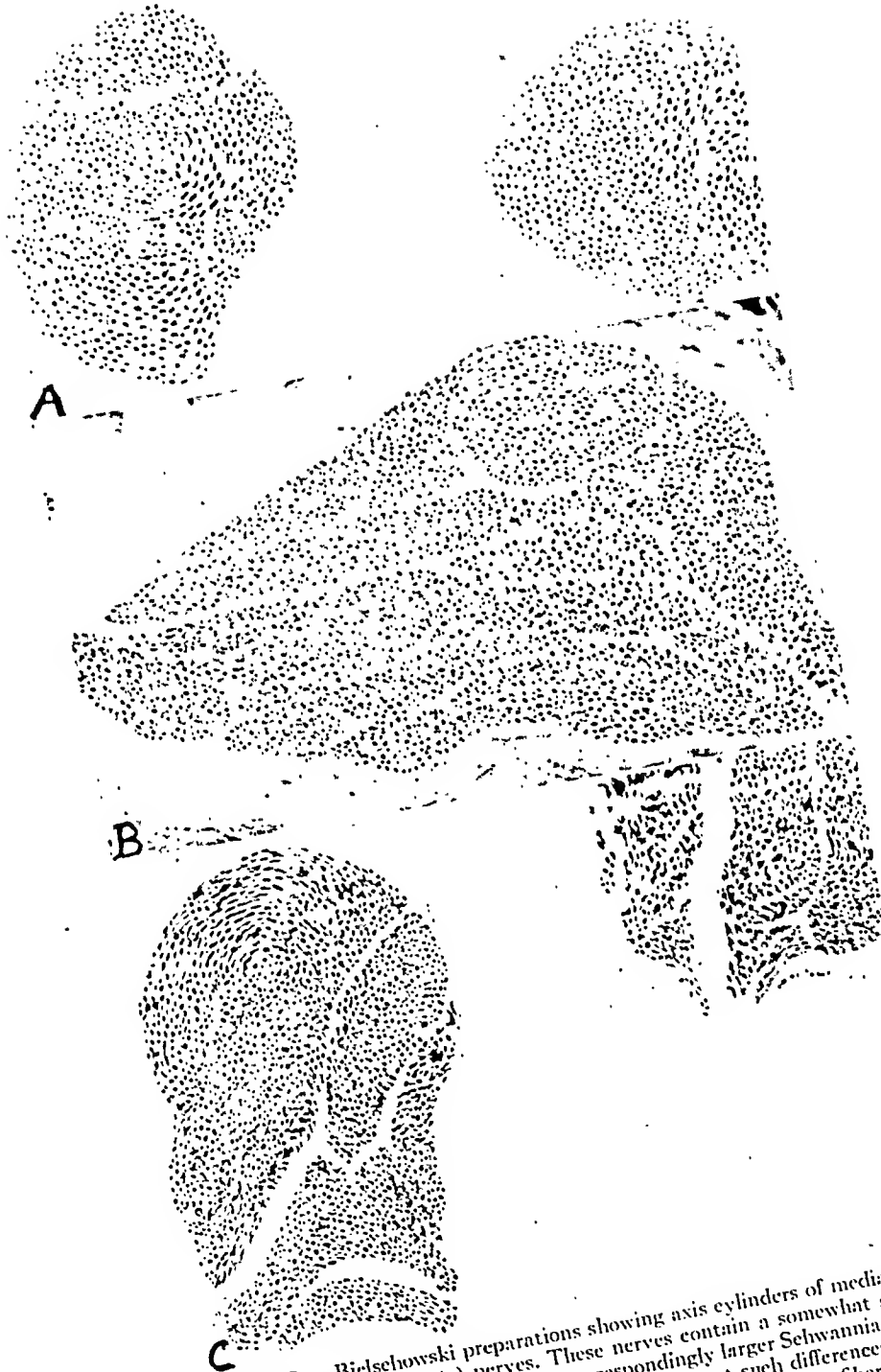


FIG. 2. Gros-Bielschowski preparations showing axis cylinders of median (A), ulnar (B) and radial (C) nerves. These nerves contain a somewhat greater number of large axis cylinders and correspondingly larger Schwannian tubes than the nerves shown in Figure 1. Whether or not such differences would prove to be important in the maturation of regenerating nerve fibers and in subsequent functional recovery remains to be determined. All nerves shown in Figures 1 and 2 were taken from an adult subject and the magnification in all instances is $\times 120$.

example, that fibers regenerating into the distal segment of a nerve containing much smaller fiber pathways than the proximal segment are restricted in their maturation to an appreciable degree.⁴ However, Simpson and Young¹¹ have shown that although very small Schwannian tubes in the peripheral stump do restrict the diameter of the entering nerve fiber, the nature of the terminal fiber connection made also controls the growth of the nerve fiber. Working with rabbits, they used strips of splanchnic nerve which contain many small medullated fibers, as grafts for somatic nerves which have considerable numbers of large nerve fibers. The axones were able to grow through the graft and reach the peripheral end organs. These fibers were found to have become nearly as large as those occurring in pieces of somatic nerve similarly grafted. They conclude that the restrictive influence of moderate-sized Schwannian tubes of nerve grafts is not severe and "though further evidence on this point is desirable the indications are that in man a piece of cutaneous nerve used as a graft in a motor nerve would not unduly restrict the growth of the motor fiber."

From the practical standpoint there is only one alternative to the use of cutaneous nerves as autografts in man and that is the employment of intercostal nerves. The intercostal nerves contain a somewhat greater number of large nerve fibers than purely sensory nerves, (Fig. 1.) Whether this difference is of practical importance in grafting would have to be decided on the basis of comparative studies in man. In the present state of our knowledge and in view of the urgency of the problem of nerve grafts, particularly in cases of war injuries, it seems justifiable to employ cutaneous as well as intercostal nerve grafts in man.

The purpose of this study has been to determine the lengths and diameters of various nerves available for use as grafts, the surgical approach to them and an estimate of the handicap resulting from

excision of the nerves. The diameters of the major nerves of the body at several different levels have also been measured. On the basis of the information dealing with nerve size it is possible to estimate the number and length of the various nerve segments necessary for the repair of defects of different magnitudes in the major nerves of the body. The length of the available nerves obtainable for grafting and their calibers will vary with the height of the individual and the degree of his physical development. The figures listed represent average measurements of nerves dissected bilaterally in a series of six cadavers of adult subjects and from observations made during instruction in the anatomy laboratory. The diameters recorded are obviously somewhat different from those which will be found at operation in view of the post-mortem changes that occur in the cadaver. Nevertheless, the variations will not be sufficiently great to nullify their intended use.

The choice of particular nerves removed to be used as grafts depends on several factors. The ease of surgical exposure of the nerves, their diameters and available lengths and the degree of disability or annoyance caused by the resultant anesthesia or scar are among the considerations which govern the selection. Incisional scars over bony prominences or areas subjected to pressure such as the dorsum of the foot should be avoided lest pain or ulceration follow. Moreover, the occurrence of large anesthetic areas on parts of extremities exposed to repeated trauma such as the feet would be undesirable because of the risk of trophic ulceration. The creation of sensory loss to the fingers is, of course, contraindicated because the resultant impairment of position sense and object recognition which constitutes a serious handicap. In certain cases the choice of a nerve for grafting will be partly dictated by the position of the patient on the operating table. However, when the need is great this limitation can be overcome by changing the patient's position during the course

of the operation in order to make the necessary incisions.

The areas of sensory deficit following excision of the various cutaneous nerves which might be chosen for grafts is shown in Figure 3 in which is also indicated the incisions used for exposing the nerves. The fields shown are smaller than the maximal sensory area of the nerve because of the overlap between adjacent nerves as demonstrated by Foerster.² An advantage of employing the intercostal nerves as grafts would be that alternate nerves could be obtained, in which case, the overlap of nerves would produce little if any loss of sensation or of motor function of the intercostal or abdominal muscles.

These considerations have guided us in formulating recommendations as to the various nerves which might be used for grafting. In dealing with an individual case one must always consider the possible gain from an operation against the counterweight of the handicap resulting from the excision of nerves to be used as a source for the graft. It is hoped that the suggestions may prove helpful in practice although they should not be considered as final. Judgment as to the most suitable nerves for grafts will have to be tempered by actual extended clinical experience.

The intercostal nerves from the sixth through the twelfth thoracic may be freed from the angle of the ribs outwards for a distance of 15 to 18 cm., generally to the mid-axillary line. Beyond this point they branch too much for use. These nerves at higher levels are more difficult to obtain because of the interposition of the scapula. Each intercostal nerve may be found close to the inferior border of the rib, between the external and internal intercostal muscles. The exposure of the nerve may be made at the scapular line which is just lateral to the paraspinal muscles. The skin and superficial muscles are incised over the rib and then retracted to expose the external intercostal muscle, the fibers of which course downwards and outwards. An incision through the external intercostal muscle will

expose the nerve close to the lower border of the rib. Care must be taken to avoid entering the pleural cavity. The nerves may then be freed backwards and forwards for the desired lengths. A skin flap with its base running along the course of a rib may be used to expose four to six intercostal spaces. The nerves vary from 1 to 2 mm. in diameter. Alternate intercostal nerves should be chosen in order to minimize the ensuing motor and sensory loss.

The branches of the intercostal or any other nerve that is chosen must be taken with the parent trunk that is to be used for the graft provided that an equal length of the branch can be freed. Otherwise, during the process of regeneration the axis cylinders may wander out along the Schwannian tubes of the branches which have been cut short and become lost in the surrounding tissue. In order to avoid this loss of axones the branches as well as the main trunk of the graft must make end-to-end contact with the peripheral stump of the nerve that is being repaired. A nerve that has profuse branchings which are difficult to follow should, therefore, not be used as a source for a graft.

One of the most favorable of the cutaneous nerves from the standpoint of its accessibility, available length and diameter is the sural nerve (S1, S2) which is formed by the union of the medial sural cutaneous branch of the tibial with the anastomotic branch of the common peroneal nerve. The nerve averages 2 mm. in diameter and may be easily exposed by a longitudinal incision along the lateral border of the Achilles tendon about 10 cm. above the tip of the external malleolus. The nerve may then be freed upwards and downwards for a total length of approximately 25 cm. or more and is relatively free from branching over this stretch. The external saphenous vein lies in close proximity to the nerve and both are superficial to the deep fascia during most of their course. It supplies a small part of the lateral dorsal surface of the foot and calf with sensation, the deprivation of which is of no significant consequence.

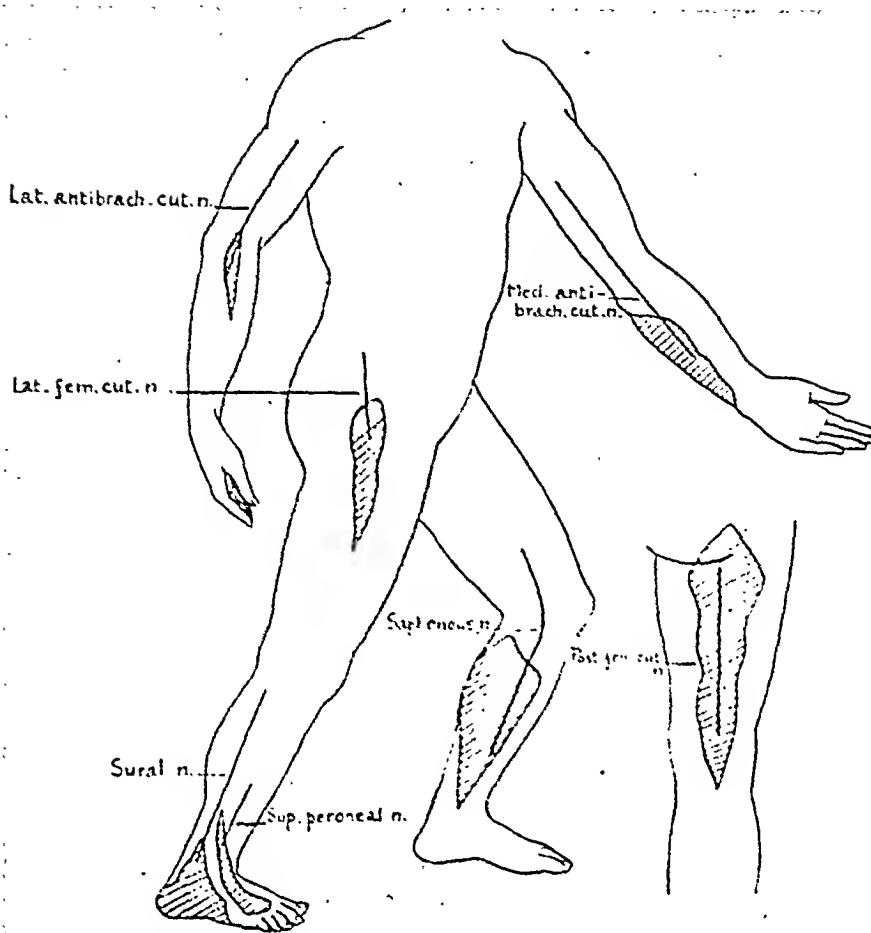


FIG. 3. The sites of incisions for exposure of the various cutaneous nerves which might be used as a source for cable grafts is indicated by heavy solid lines. The autonomous areas, which represent the zones of sensory deficit following severance of the nerve, are shown.² The autonomous area (supplied exclusively by one cutaneous nerve) is, of course, much smaller than the maximal area (which remains when all neighboring nerves to this region are severed); this has been demonstrated by Foerster.

The lateral femoral cutaneous nerve (L2, L3) is approximately 2 mm. in caliber as it passes from under the inguinal (Poupart's) ligament. It enters the thigh within 1 to 2 cm. of the attachment of Poupart's ligament to the anterior superior iliac spine. The nerve is rather flat in this region and tends to adhere to the superficial surface of the sartorius muscle. The fasciculi of the nerve course downwards and outwards whereas those of the muscle run downwards and inwards. The nerve is exposed by an incision just medial to the anterior superior iliac spine. It divides into several branches within a few centimeters distal to Poupart's ligament. One of the main branches of the nerve, approximately 1 mm. in diameter, may be obtained

for a total length of 15 to 20 cm. Following its excision the loss of sensation over the anterolateral region of the thigh constitutes no handicap to the patient.

Approximately 15 cm. of the posterior femoral cutaneous nerve (S2), which is 2 mm. in diameter, is available for grafting. The nerve may be exposed by a longitudinal incision commencing superiorly at the gluteal crease on a line from the tuberosity of the ischium to the middle of the popliteal fossa. Its course bisects the hamstring muscle mass almost exactly. The nerve lies at a rather deep plane close to the fascia lata in which it may be enmeshed. Because of the absence of exact guiding landmarks and the fact that it blends with the fascia over the hamstring

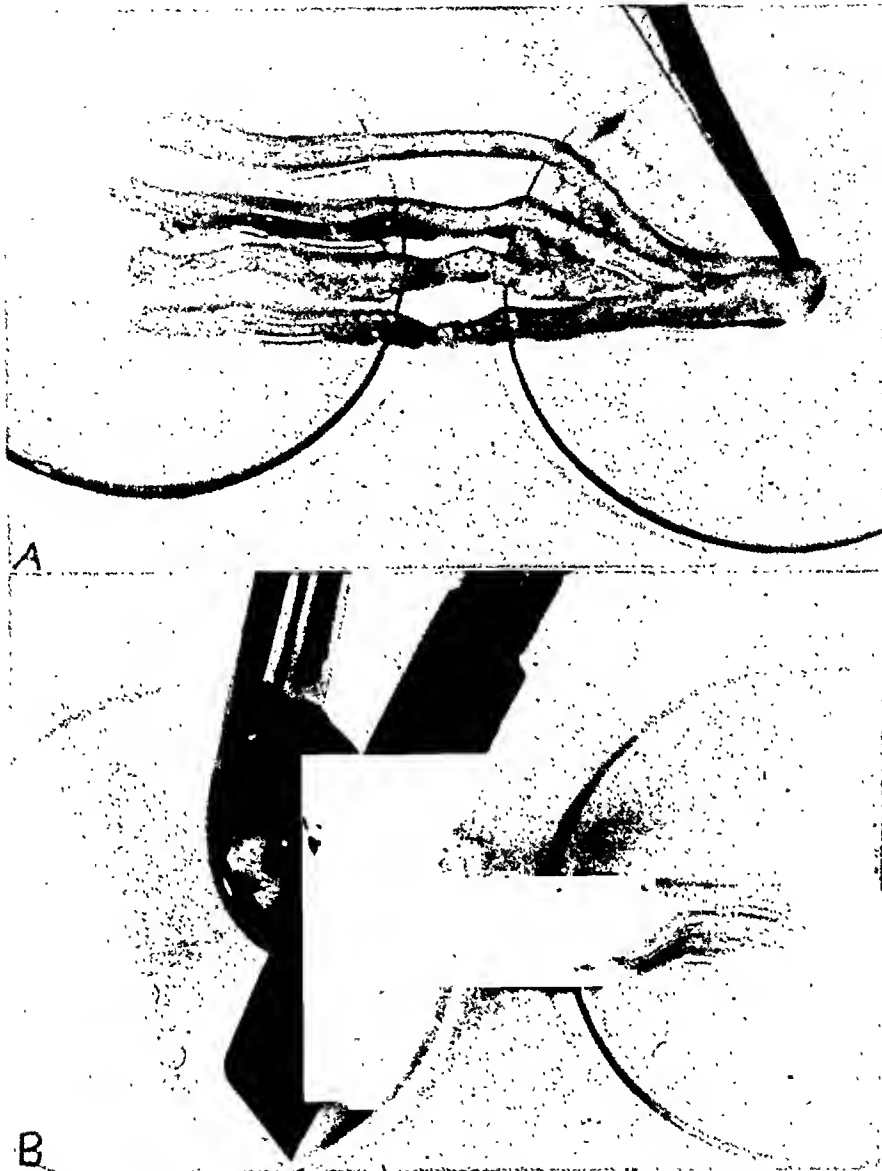


FIG. 4. The technic of forming a cable graft is shown. Plasma is dropped on the terminal centimeter of the nerve strands placed in a watch glass and the ends are fashioned into a cable (A). Five to ten minutes are allowed for firm union to occur. After the other ends have been united similarly, thin slices are excised with the aid of the special nerve holder and a razor blade mounted on a needle holder (B). Flat cut surfaces for contact with the host nerve are thus obtained.

muscles the nerve is somewhat more difficult to identify than other cutaneous nerves.

The superficial peroneal nerve (L₅, S₁) is obtainable for a length of 15 cm. after supplying motor fibers to the peroneus longus and brevis. The diameter of the nerve or of its two branches collectively (medial and intermediate dorsal cutaneous

nerves) is 1 to 2 mm. The nerve may be exposed by a longitudinal incision centered about 12 cm. above the lateral malleolus. It lies in the groove between the peroneal muscles and the extensor digitorum longus at the junction of the lateral third and the medial two-thirds of the anterolateral quadrant of the leg.⁸ The nerve emerges from the deep fascia at this point. It



FIG. 5. The method of suturing the cable graft to the host stumps is shown. The ends of the cable and host nerve are accurately apposed on the wire rails of the latex molds and autologous unmodified plasma is added (A). After clotting has occurred the wire rails and clips of the molds are withdrawn and the molds removed leaving the suture sites surrounded by plasma clot (B). The middle segments of the cable graft have been separated in the tissue bed so as to allow vascularization of the individual strands to occur more readily. The graft must be long enough to permit spreading of the filaments in its bed. Since there is no tension on the suture site the use of tension sutures is unnecessary. The use of tantalum foil or any other impermeable membrane to surround the graft is absolutely contraindicated since blood vessels are thereby prevented from entering the graft and the occurrence of necrosis is favored.¹³ The above two photographs were taken at operation on the sciatic nerve of a dog.

supplies a portion of the dorsal surface of the foot with sensation, the loss of which may be a real annoyance to an individual. For this reason, it is well to avoid use of this nerve for grafting unless the necessary supply of nerves from other sources is exhausted.

A long, though variable length (approximately 40 cm.) of the saphenous nerve may be obtained for grafting. It is rather small (1 mm. or less in caliber) and branches considerably as it courses through the leg,

although a long segment of fairly thick nerve (2 mm.) may be obtained in the thigh where it is unbranched. The nerve may be exposed by an incision extending from the internal malleolus along the medial border of the tibia where it lies close in relation to the saphenous vein. It may then be followed upwards through Hunter's canal although removal of the nerve in the thigh requires a rather extensive dissection when this technic is utilized.



FIG. 6. Plasma clot suture can be carried out without the latex mold by building a wall around the nerve ends utilizing pieces of fat or subcutaneous tissue for this purpose. The stump of the nerve and graft are placed on pieces of tissue so that the lower surface of the suture site can be covered with plasma as well as the upper. After the plasma has clotted and the nerve suture completed, the wall should be dismantled by carefully separating the clot from it and discarding the blocks. This method is useful when, because of the lack of space or for some other reason, the latex mold cannot be used. The mold, formed of fat, should be oval in shape, in the style of the latex mold. It appears foreshortened because of the angle at which the photograph was taken at operation upon a patient.

Among the nerves of the upper extremity there are two which lend themselves for use as grafts, the lateral and medial antibrachial cutaneous nerves. The lateral (C₅, C₆, C₇) which represents the terminal branch of the musculocutaneous nerve, measures about 2 mm. in diameter and may be exposed by a longitudinal incision just lateral to the tendon of the biceps brachii muscle about 2 to 3 cm. above the crease of the elbow. The incision may be extended distally in a straight line to the styloid process of the radius. The nerve emerges from beneath the lateral border of the tendon and courses underneath the cephalic vein. It may be followed upwards to the middle of the arm where it lies between the biceps brachii and the brachialis muscles which receive their innervating branches above this point. Downwards the nerve may be traced into the forearm. The nerve is obtainable for a distance of 25 cm. The loss of sensation

following excision of the nerve is of little concern to the patient.

The medial antibrachial cutaneous nerve (C₈, T₁), although close to the large vessels on the medial surface of the arm, may be quite easily exposed by an incision along the course of the brachial artery in the upper third of the arm. It lies superficial to the brachial vessels underneath the deep fascia. It may be obtained throughout its course in the arm where it measures 2 to 3 mm. in diameter. The median nerve lies lateral and anterior to it and the ulnar nerve occupies a position posterior to the brachial artery. A segment of nerve, 20 cm. or more in length, may be obtained in the arm. The nerve divides in the lower third of the arm into two branches which pass over the medial epicondyle. An additional stretch of 15 to 20 cm. of each branch of the nerve may be obtained in the forearm. It supplies sensation to the medial aspect of the forearm as far as

the wrist. The anesthesia following its excision is of little annoyance to the patient.

Knowing the diameters and the available lengths of the various nerves chosen as grafts, one can calculate roughly the length of cutaneous or intercostal nerve necessary to fill defects in various major nerves, the approximate calibers of which are shown in Table 1:

TABLE 1
AVERAGE DIAMETERS OF MAJOR NERVES OF EXTREMITIES

	MM.
Sciatic (mid-thigh).....	8.3
Tibial (popliteal fossa).....	4.7
Common peroneal (popliteal fossa)...	3.6
Posterior tibial (ankle).....	3.5
Femoral (Poupart's ligament).....	4.8
Median (origin).....	4.1
Radial (origin).....	4.3
Ulnar (origin).....	3.8
Median (wrist).....	3.5
Ulnar (wrist).....	2.5

The cross-sectional areas of nerves (considered as true cylinders for the purpose of our calculation) vary according to the squares of their diameters. Thus the cross-sectional area of a nerve 4 mm. in diameter is four times that of a nerve 2 mm. in diameter so that four strips of the latter nerve would be required to fill a gap in the former. Let us assume, for example, that a 7 cm. gap in the median nerve just above the wrist is to be repaired and that one chooses the intercostal nerves for grafting. The median nerve at the level of the wrist averages 3.5 mm. and the intercostals 1.5 mm. in diameter so that squaring these figures the ratio becomes 12.3:2.3. In other words six strips of intercostal nerve would be required to repair the gap in the median nerve. It would be possible to obtain a segment of one intercostal nerve long enough to provide two strips of graft. Three intercostal nerves would therefore have to be obtained although other nerves, possibly thicker ones, such as the median anti-brachial cutaneous nerve, could be chosen in which case fewer strips would be required. It is advisable to allow an extra

centimeter or two in length for the cable graft in order to avoid any tension on the suture line and to allow for spreading of the strands in the tissue bed so that vascularization may more readily occur.¹³

The method of forming cable grafts and uniting them to the host stumps is illustrated in Figures 4 and 5. The use of the plasma clot technic is virtually essential for the suture of the cable grafts since thread suture of the graft results in great damage to the nerves and less satisfactory union. If the nerves to be used for the cable graft vary somewhat in thickness at their ends, the polarity of some of the strands may be reversed in order to equalize the two ends. The polarity of a graft has no effect upon regeneration that occurs through it. If the distal stump of the nerve is appreciably smaller than the proximal one, the variation in caliber of the component nerves of the cable may be utilized to form a graft that fits properly with the stumps of nerve at both ends.

When using a graft to repair a nerve gap the thought occurs as to whether one should attempt to shorten the gap by flexing the neighboring joints in order to reduce the amount of necessary graft. It is true that the longer the graft the more likelihood there is of its necrosis and fibrosis with consequent greater hindrance to the down-growth of nerve fibers. On the other hand, the subsequent extension of a limb which has been very sharply flexed in order to perform end-to-end suture of a severed nerve may result in considerable damage to that nerve.^{3,6} However, satisfactory functional regeneration does occur when nerves are sutured with joints moderately flexed. We have adopted a compromise measure for the time being in view of the lack of data bearing on this point. It is recommended that grafts should be introduced into defects with joints only slightly flexed (10° to 20°) and kept in this position for a period of three weeks before extension is allowed. Further experience with the results of grafts in humans may alter this viewpoint. A

three-week period of immobilization is chosen because recent experiments of one of us (I. M. T.) as yet unpublished, have shown that in rabbits the sciatic nerve sutured with autologous plasma clot achieves a tensile strength value equal to that of the intact nerve within this period of time. It is unlikely that any very appreciable difference in this time interval of nerve healing occurs in humans. It is to be understood of course that the bed for a nerve graft should be well vascularized and relatively free from scar tissue, an ideal, however, which is unfortunately often unobtainable in practice.

The results following the use of nerve grafts cannot be expected to equal those of end-to-end suture of nerves under favorable circumstances. But in spite of the uncertainty of the results, the use of grafts is justifiable when end-to-end suture of nerves cannot be done. Reconstructive orthopedic operations may be considered if nerve grafting results in failure. When the use of a graft is found to be necessary, the operation should not be delayed inasmuch as shrinkage of the Schwannian tubes that occurs in a peripheral stump that has been left uninervated for a long period of time may restrict the increase in nerve fiber diameter and thereby impair the functional result even though the correct connections are re-established and the muscle kept in fairly good condition.

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THE LOCAL USE OF ICE AFTER ORTHOPEDIC PROCEDURES*

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IT is the purpose of this paper to point out the benefits of locally applied cold in orthopedic surgery. Ice takes up heat rapidly from its surroundings. When the local temperature of a part is reduced, the tissue metabolism is decreased, the local blood supply is diminished and sensory end organs are dulled.

According to Jensen,¹ the range of temperature in storage ice destructive for certain bacteria is from -2°C . to -5°C . (28.4°F . to 23°F .). This range of temperature is considered to be germicidal for some bacteria. At lower temperatures, down to that of liquid air, bacteria like the typhoid bacillus remain viable nineteen months or longer. According to Baldyрева,² the temperature of natural ice varies between 0°C and -5°C . (32°F . and 23°F .).

Fay and Henny³ in their monograph demonstrated the benefits of local ice application for the relief of pain in metastatic carcinoma. They pointed out that this method of refrigeration when applied to the area of metastatic involvement brought about prompt relief of pain as well as temporary improvement in the general nutrition of the patient.

Krieg⁴ has used ice postoperatively on the breast, abdomen and neck, and states that the temperature induced by the application of ice caps is 6°C . (42°F .). In Krieg's opinion his patients had less postoperative discomfort, required fewer narcotics and had fewer postoperative complications when ice packs were used.

Allen's⁵ experimental work in the use of ice indicates that reduction in local temperature in the ligated legs of rats reduces the danger as regards both gangrene and

shock. He states that in the rat "whenever the temperature can be efficiently maintained at 2°C . the limbs can survive asphyxia for a long period, the maximum of which has not been established but which is certainly more than fifty hours." In a later paper⁶ he points out that "If an operation, shockless in itself, has left damaged tissues which may set up post-operative shock, this danger can be bridged by temperature control. Shock production by tissues is inhibited in proportion as their temperature is reduced." When threatening signs of loss of vitality in skin or other tissues appear, the blood supply cannot be increased effectively, but the metabolism can be cut down by reducing the local temperature, which in turn decreases the demand for oxygen and nutrition. Allen mentions that healing in the presence of ice is adequate and firm and that the danger of thrombosis is minimized.

EXPERIMENTAL

In order to determine the fall of temperature inside a plaster cast when ice is applied to the outside, leg and arm cylinders of varied thicknesses were prepared of plaster of paris rolls and sheet cotton. In each case the casts were removed in fifteen minutes, fitted together and held with an additional layer of plaster. A Fahrenheit thermometer was placed inside the empty cylinder and the cylinder ends plugged with gauze. Two covered ice bags were then wrapped on the cylinders and held in place with bandage. It was found repeatedly that within two hours the temperature inside the cast dropped to 40°F ., and within three hours after the application of the ice caps to 33°F .

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† Aided by a Grant from the National Foundation for Infantile Paralysis, Inc.

By refilling the ice bags every seven hours the temperature inside the empty cylinder could be maintained at from 32°F. to 34°F.

TABLE I
SURGICAL PROCEDURES AND PLASTER CASTS

Type of Surgery	Cases with Ice			Cases without Ice		
	No. of Cases	No. of Casts Applied	No. of Casts Split	No. of Cases	No. of Casts Applied	No. of Casts Split
Knee surgery.....	66	30	2	82	39	24
Wrist fusions.....	2	2	2	4	4	4
Foot surgery.....	43	30	3	51	36	23
Hip surgery.....	28	13	0	25	6	0
Fractures.....	57	57	2	72	72	35
Tendon surgery.....	18	17	0	58	58	10
Shoulder surgery.....	8	2	0	6	1	0
Bone grafts.....	20	20	1	6	6	4
Tumors.....	28	6	0	60	19	4
Sequestrectomies and saucerizations.....	25	10	1	67	42	17
Osteotomies.....	12	12	0	22	22	11
Manipulations.....	24	0	0	4	0	0
Nerve surgery.....	8	7	0	7	7	0
Elbow fusions.....	1	1	0	0	0	0
Amputations.....	6	0	0	15	0	0
Totals.....	345	207	11	479	312	132
Percentage of casts split.....			5.31%			42.3%

By placing a thermometer beneath soft bandage dressings, directly upon the skin of patients on whom ice was used postoperatively it was found that the temperature dropped to 44°F. within two hours and to 41°F. within four hours. The temperature could be maintained at 41°F. thereafter if the ice caps were refilled every six hours. In an extremity sheet cotton and plaster cast a thermometer when placed next to the skin was found to remain at 41°F. if covered ice bags were wrapped snugly onto the cast and refilled every six hours. The temperature at the hip or shoulder beneath a plaster spica could not be held lower than 50°F. The method has not been used in the postoperative care of spine fusion cases.

METHOD OF APPLICATION

Immediately postoperatively the cloth covered ice bags are applied directly to the plaster or soft bandage over the operative site. A sufficient number of ice caps should

be used to surround the extremity completely at the operative site. When used on the extremity the bags can be held in place

TABLE II
WHITE BLOOD CELL COUNTS DURING THE FIRST SEVENTY-TWO HOURS AFTER OPERATION

White Blood Cell Count	No. of Patients with Elevations					
	First Postoperative Day		Second Postoperative Day		Third Postoperative Day	
	Ice	No Ice	Ice	No Ice	Ice	No Ice
10,000 to 15,000	42	140	9	40	4	21
15,000 to 20,000	1	15	2	17	1	5
Over 20,000	0	5	0	2	0	1
Total over 10,000	43	160	11	59	5	27
Percentage over 10,000	12.4%	33.4%	3.18%	12.3%	1.4%	5.6%

by elastic bandages. On the hip or shoulder cases scultetus binders may be used. The ice caps are refilled every four hours and are used for forty-eight hours postoperatively. The accumulated air in the ice caps should be released at hourly intervals to allow them to hug the cast snugly.

RESULTS

Eight hundred twenty-four consecutive cases have been studied. Following surgery or manipulation ice caps were used on 345 patients; ice was not used on 479 patients. Table I list the types of procedures included in this series. In those patients on whom ice was used postoperatively 207 plaster casts were applied. Eleven (5.31 per cent) of these casts had to be split because of pain, swelling or other signs of circulatory embarrassment. All eleven casts were split within the first seventy-two hours. In contrast, of the 312 casts applied when no ice was used, 132 (42.3 per cent) had to be split within seventy-two hours.

Of the patients treated with ice on whom postoperative white blood cell counts were done, 12.4 per cent showed white blood cell counts of over 10,000 on the first postoperative day, 3.18 per cent on the second postoperative day and 1.4 per cent on the

third day. Of the patients not treated with ice on whom postoperative white blood cell counts were done, 33.4 per cent showed white blood cell counts of over 10,000 on the first postoperative day, 12.3 per cent on the second postoperative day and 5.64 per cent on the third day.

TABLE III

TEMPERATURE, PULSE AND RESPIRATION DURING THE FIRST SEVENTY-TWO HOURS AFTER OPERATION

Elevation	Ice		No Ice	
	No. of Cases	Per-cent-age Ele-vation	No. of Cases	Per-cent-age Ele-vation
Temperature higher than 38.3°C.....	39	11.3	111	23.18
Pulse rate over 115 per minute.....	39	11.3	120	25.05
Respiratory rate greater than 20 per minute....	9	2.6	70	14.6

The postoperative temperature, pulse and respiration have remained nearer normal in those patients on whom ice was used. In the group in which ice was not used, 111 (23.1 per cent) patients had temperature elevations of 38.3°C. (101°F.) or over for the first seventy-two hours postoperatively. Of the 345 cases in which ice was used, thirty-nine (11.3 per cent) had a temperature elevation over 38.3°C. for the immediate seventy-two hours postoperatively. A pulse rate of over 115 per minute for at least three postoperative days was noted in 120 (25.0 per cent) patients out of the group in which cooling was not used. When ice was used, thirty-nine (11.3 per cent) cases showed a pulse rate over 115 per minute in the seventy-two-hour period after surgery. The respiratory rate was found to run higher than 20 per minute for seventy (14.6 per cent) patients where ice was not used. When ice was used, nine (2.6 per cent) cases had a respiratory rate of over 20 for the first three postoperative days.

When no ice was used postoperatively sixty (12.5 per cent) patients developed complications such as ileus, circulatory embarrassment, thrombophlebitis, etc., severe enough to warrant special attention. When ice was used, nineteen (5.5 per cent) patients developed complications severe enough to demand special attention.

TABLE IV
POSTOPERATIVE COMPLICATIONS

Complication	No. of Cases	
	Ice	No Ice
Gangrene.....	1	2
Wound slough.....	0	2
Gastrointestinal upset.....	4	17
Paralytic ileus.....	11	12
Wound break down.....	3	9
Hematoma or hemarthrosis.....	0	16
Thrombophlebitis.....	0	2
Total.....	19	60
Percentage.....	5.5%	12.5%

A survey of the average of total amount of narcotic used by each patient for the seventy-two hour period following surgery is given in Table v. The figures were arrived at as follows: the type and amount of narcotic taken by each patient during the postoperative period and the quantity used by all patients having a similar type of surgery was computed. This latter amount was then divided by the total number of patients in each category.

A subjective factor was repeatedly demonstrated by the patients who received local applications of ice to the operative site. Voluntary comments concerning the relative comfort when ice was used about the operative site were gratifying. When ice was discontinued after the first forty-eight-hour postoperative period, frequently the patient asked that it be replaced because of the relief of pain which it afforded. The patient upon whom ice was used rested more comfortably, took fluids with greater ease and demonstrated a normal appetite

TABLE V
AVERAGE* OF TOTAL AMOUNT OF NARCOTICS REQUIRED DURING THE FIRST SEVENTY-TWO HOURS
AFTER OPERATION

Type of Surgery	Cases with Ice				Cases without Ice			
	Codeine mgm.	Morphine mgm.	Demerol mgm.	Pantopon mgm.	Codeine mgm.	Morphine mgm.	Demerol mgm.	Pantopon mgm.
Knee surgery.....	76.5	8.5	6.0	2.8	256.0	36.4	100.0	
Wrist fusions.....	360.0	15.0			610.5	30.0		
Foot surgery.....	70.4	14.0	20.0		260.0	28.4	19.6	
Hip surgery.....	70.7	18.4			240.6	62.6	26.5	
Fractures.....	48.6	5.4			204.0	23.4		
Tendon surgery.....	30.3	6.8	3.1	1.2	249.3	9.2	16.4	
Shoulder surgery.....	360.5	5.0			406.0	30.5		
Bone grafts.....	98.0	15.1	2.8	.001	515.3	15.0		
Tumors.....	49.7	2.3	5.3		162.4	18.3	6.0	
Sequestrectomies and saucerizations	72.0	10.1			195.0	15.1		
Osteotomies.....	41.3	1.0	7.7		250.5	26.0		
Manipulations.....	27.0				115.0	6.0		
Nerve surgery.....	13.1	1.5	12.5		75.7			
Elbow surgery.....		60.0			219.0	50.8		
Amputations.....	20.0	13.9						
Average per case.....	89.2	11.8	3.8		.26	268.5	25.1	12.0
Average dosage in grains per case	1.4	1.9	.06		.004	4.2	.4	.19

* The figures were arrived at as follows: The type and amount of narcotic taken by each patient during the postoperative period, and the quantity used by all patients having a similar type of surgery was computed. This latter amount was then divided by the total number of patients in each category. As a rule, codeine was given in doses of 60 mg., morphine 12 mg., demerol 50 mg. and pantopon 15 mg.

sooner following surgery than when no ice was used. The entire convalescent period of all patients on whom ice has been used has been satisfactory.

CONCLUSIONS

The skin temperature beneath soft dressings or under padded plaster casts can be reduced by the local application of covered ice bags.

On 345 patients when ice was used locally: in the seventy-two-hour period following surgery fewer casts were split; the temperature, pulse and respiration were lower; white blood cell counts were nearer normal; postoperative complications were fewer; and the amount of narcotic per patient was reduced.

Subjectively, the patients who have ice applied locally fare better in all respects

than the patients who have no ice application during the postoperative period. The postoperative use of ice applied locally to the operative site is a valuable adjunct in the treatment of surgical patients.

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TRANSSCROTAL ORCHIDOPEXY IN ADULTS

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SOME degree of failure of descent of one or both testes occurs in 3 per cent of all males according to Strauss.¹ co-exist with hernial defects, the fate of the orchid at the time of herniorrhaphy must be decided. Four procedures may be

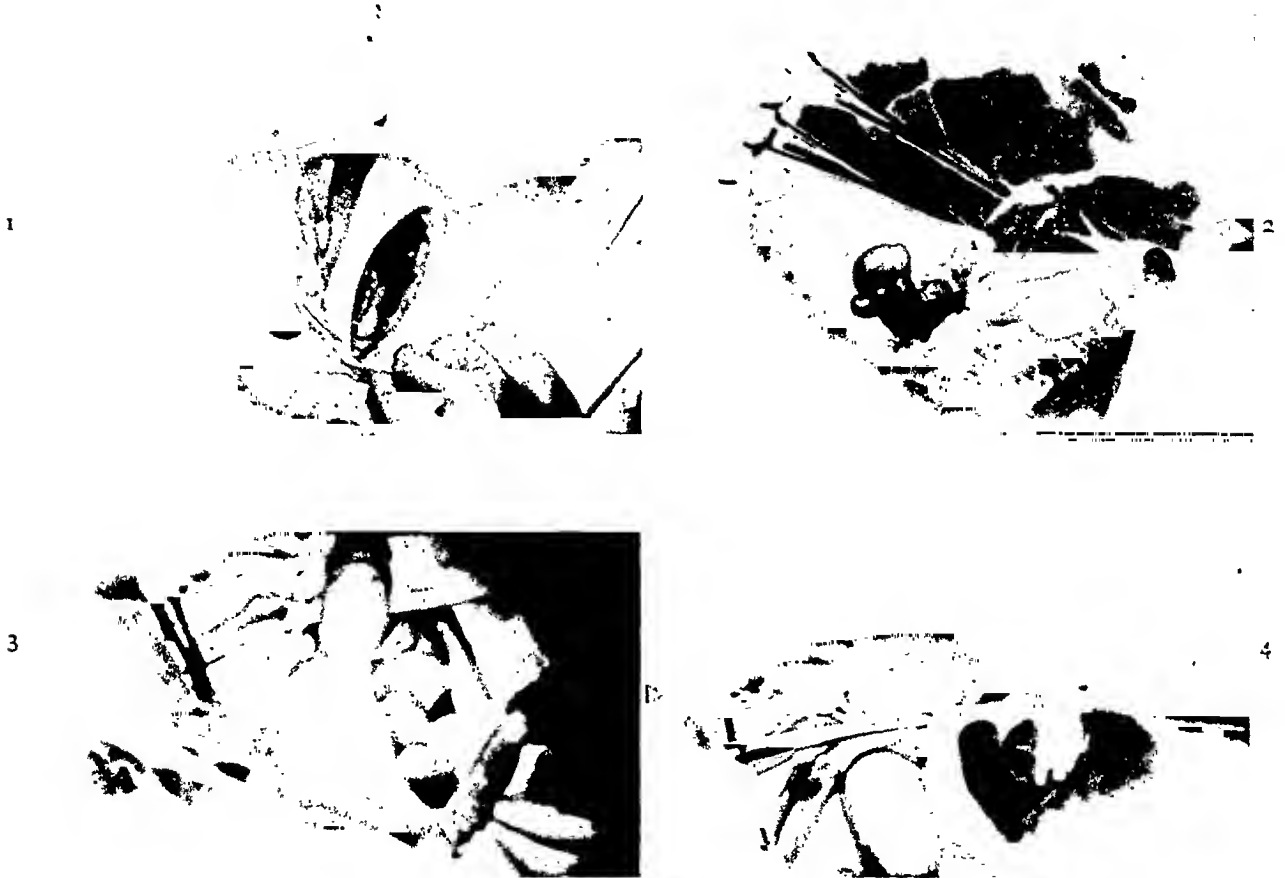


FIG. 1. Skin incision with ectopic gland overriding anterior shelf of external inguinal ring.

FIG. 2. Opening of inguinal canal and freeing cord; hernia repaired.

FIG. 3. Finger dissection of empty scrotal sac.

FIG. 4. Median raphe of scrotum held and skin and Dartos fascia incised on the distal side.

These abnormalities are common because, in the opinion of Moore and Tapper² the gubernaculum testis is liable to erratic fixation to the pubic arch, scrotal wall, or inguinal ligaments so that proper traction and descent of the testis into its normal position is prevented. Once the descent is arrested the cremaster muscles hypertrophy. This, along with bands of adhesions about the shortened cord, fixes the testis within the inguinal canal.

Since practically all undescended testes

followed: (1) To leave the gland in the inguinal canal following hernial repair; (2) to replace the gland within the abdominal cavity; (3) to perform castration, and (4) to do orchidopexy.

Leaving the testicle in the canal after herniorrhaphy lends itself to the possibility of recurrence of herniation and may result in painful testis. These conditions occur because the gland, lying partially free in the inguinal canal between the layers of the abdominal wall, is subjected to a



FIG. 5. Opening of mid-serotal septum from proximal serotal incision.

FIG. 6. Passage of a curved hemostat through serotal fenestra.

FIG. 7. Grasping gubernaculum of testis through new canal.

FIG. 8. Transposition of testis into distal side of scrotum.

piston-like action which tends to create a reherniation of the parietal peritoneum.

Placing the gland in the abdominal cavity creates a potential source of further trouble because of continued degeneration.

Castration is a crippling procedure and should be done only if the gland is atrophic or too high for surgical descent.

Fixation of the misplaced testis has, in the past, been best accomplished by the Torek³ operation, a correction which requires several stages at intervals of from two to four months. This makes it militarily impracticable. The Bevan⁴ operation attempts to fix the testis within the scrotum by partial closure of the neck of the serotal sac. Failures frequently follow this method and are due to postoperative contraction of the cord with resultant constriction of the blood supply and atrophy of the gland.

The method of Ombredanne⁵ is a possible

choice; however, a search of the literature fails to show that it has ever been attempted in the adult. This means of orchidopexy utilizes the serotal septum as the retaining point for the incompletely descended testis. In 1910, Ombredanne reported twenty-one cases of unilateral and four cases of bilateral fixations. The patients were all children ranging from six to sixteen years of age. Hagenbaek,⁶ as late as 1943, reported eighteen such operations upon boys with good results.

Applying Ombredanne's procedure to the adult the operation is as follows: An incision is made 8 to 10 cm. in length from the pubic tubercle to the anterior superior spine parallel to Poupart's ligament. When the subcutaneous fascia is divided, the arrested testicle is usually found on the anterior shelf of the external inguinal ring. (Fig. 1.) The fascia of the external oblique is incised in a retrograde

manner to conserve the ilio-inguinal nerve and the external ring is carefully divided. This exposes the contents of the inguinal canal. The gubernaculum is carefully separated from its attachment and adhesions to the rest of the cord are separated, freeing the entire cord from its bed. The hernial defect is identified and the sac isolated and removed at its highest point to give the maximum length to the shortened cord. Retroperitoneal blunt dissection of the cord as it emerges from the abdominal cavity gives additional mobility. If further lengthening is required, the infundibuliform fascia covering the cord can be opened and the cremasteric muscles removed. In addition partial separation of the pampiniform plexus from the remaining cord structures may also be done. (Fig. 2.) Repair of the hernial defect is then accomplished, first strengthening the floor of the canal by reduplicating the transversalis fascia and utilizing the conjoint tendon which is approximated to the shelving portion of Poupart's ligament, care being taken to form the new internal inguinal ring. The fibers of the external oblique are next split at right angles and imbricated above and below the new internal ring in such a manner that the cord emerges at a greater angle from the abdominal cavity. This prevents acute angulation when healing takes place. When the repair has been accomplished and the length of the cord found adequate, the inguinal wound is temporarily abandoned and the scrotum prepared for the reception of the testis. The index finger is passed down the empty scrotal neck and the proximal sac opened by finger dissection. (Fig. 3.) Two Allis clamps are then placed on the median raphe of the anterior surface of the scrotum and a lateral incision one inch in length is made parallel to the raphe on the distal side. (Fig. 4.) This incision is carried through the scrotal skin and dartos fascia after which a space is made alongside the normal testis to accommodate the other. The finger within the empty scrotal sac is pushed against the



FIG. 9. Repair of scrotum and inguinal incisions.



FIG. 10. Left orchidopexy three months postoperatively.

scrotal septum which emerges through the scrotal incision. The septum is incised and widened to permit the passage of the ectopic gland. (Fig. 5.) A non-absorbable suture is placed at each end of the septal incision to narrow the opening after the testis has been delivered. At this point, a large curved Kelly forceps (Fig. 6) is passed through the septal fenestrum, up through the empty scrotal sac, and the gubernaculum of the mobile testis is caught. (Fig. 7.) By gentle traction the testis and cord are gradually drawn downward until the testicle emerges through the septal incision into the scrotal wound. (Fig. 8.) The sutures in the septum are then tied snugly about the cord so that the gland cannot retract and the orchid is placed in the scrotum beside the normal one. Dartos fascia and skin are closed in separate layers.

Except in the septal closure, catgut sutures are used throughout. (Fig. 9.) The remaining hernial wound is closed in layers and a dry dressing applied. Scrotal support is advised.

The septum should be opened in the most caudal position consistent with the length of the cord. When a congenital hernia is present and the testis is in the hernial sac, it is best to do a bottle-type of operation rather than a radical one because of the lessened possibility of postoperative hemorrhage. Drainage is not advisable in transcrotal orchidopexy. Figure 10 shows a right orchidopexy three months postoperatively.

Unlike the Torek operation postoperative traction in these cases is flexible because of the elastic pull and tenting of the scrotal septum. Ischemia is less likely to result. Since no fixation sutures have been placed to restrict the movement of the testis completely, it can adjust itself more readily to the length of the cord and the available blood supply. This may explain the fact that in all but one of our cases there has been a permanent increase in the size of the transcrotal testis. In one case in which there was obvious deficient length of the dissected cord, a painful testis did result for a few months which shows the importance of obtaining adequate length at the time of operation.

We believe that if orchidopexy is to be undertaken, the aberrant testis should be from one-half to two-thirds the size of the normal testis. The comparison should be made carefully for the size of the testes vary greatly.

The Ombredanne procedure with some modification was carried out in ten cases of unilateral undescended testis and hernia in patients varying from eighteen to thirty-two years of age. Cosmetic results have been gratifying and psychic improvement was noted in all cases. An additional advantage to this method is the fact that the time required for complete healing was no greater for the combined operative hernias.

CONCLUSIONS

Transcrotal orchidopexy was performed in a small series of adults with undescended testes and hernia. In one patient an undescended testicle complicated a strangulated hernia; another patient had had an unsuccessful Torek operation prior to induction. The first of these operations was done two years ago and has, as the others, been entirely satisfactory.

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A COMPARISON OF INTRAVENOUS AMINOPHYLLIN WITH THE COMMON DRUGS IN BILIARY COLIC

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IN this paper an endeavor was made to evaluate the use of aminophyllin in biliary colic, and to secure an appreciation of the comparative value of the common drugs used in biliary colic with aminophyllin. The cases used were not selected. They were consecutive in their admission both in the emergency room and on the wards. The latter were followed from the accident room to the surgical ward, and thence to the operating theater. This latter procedure enabled us to appreciate truly the value of the compound used.

The literature is very scanty in regard to the worth of aminophyllin in the use of biliary surgery. Gladstone and Goodman¹ report eight cases in which they used it in biliary colic with extremely good results. Butoch, McGowan and Walter² showed in their experiments that morphine and codeine raise intrabiliary pressure, while atropine and aminophyllin decrease it. The former drugs relieve pain by action on the central nervous system, while the latter act directly on the smooth muscle. The first men to use aminophyllin orally and intravenously were Mears and Delor.³ They use it in a few cases of biliary colic.

To evaluate the drug properly, I asked the admitting physicians of a busy city hospital to use it in biliary colic following the use of other antispasmodics and narcotics. This I thought would give us a true comparative estimate of the value of the drug.

Eleven consecutive cases were seen in the emergency room. Some of the typical histories are herein presented. The others will be briefly summarized in a following paragraph.

CASE REPORTS

CASE 1. Mrs. R. G., age forty-six, was admitted July 3, 1945, to the accident room complaining of pain in the right upper quadrant for one and half days. This pain was accompanied with nausea and vomiting and followed the ingestion of a particularly heavy meal that was well spiced. The patient stated she had been having recurrent attacks of dull, aching pain in the same region for a few years. However, this was the first time that it became so severe. The day of the onset she had been given a hypodermic by her physician. The pain at no time was ameliorated but seemed to increase the day of admission, so that at the time of admission the pain radiated to the region between her scapulae.

On examination the temperature was 99°F., respirations 20, blood pressure 128/84. The patient was a middle aged female rather obese crying in pain. The physical examination was negative except for the abdominal findings. The right upper rectus was spastic and markedly tender. No other masses were palpable.

A laboratory work-up could not be obtained until the patient would consent to be admitted. However, a presumptive diagnosis of biliary colic was made. Morphine sulfate gr. $\frac{1}{4}$, and atropine sulfate gr. $\frac{1}{150}$ were administered. When no relief was obtained in twenty minutes, aminophyllin was given intravenously. The $7\frac{1}{2}$ gr. were injected slowly. In five minutes by the clock the patient had relief of pain. This case was really remarkable in the complete alleviation of symptoms.

In September of the same year, the patient again visited the emergency room with a similar episode after eating "cold cuts." This time nitroglycerine gr. $\frac{1}{100}$ was given without relief. This was followed by erythrol tetranitrate, and after ten minutes by morphine sulfate and atropine sulfate in the usual dosage as given above. When no relief was obtained in

thirty minutes, aminophyllin was injected. In five minutes there was the same spectacular result as formerly. The patient refused hospitalization as she did before.

This case merits discussion. It is without doubt a case of recurring biliary colic which clearly shows the value of aminophyllin and the rapidity of its action.

CASE II. Mrs. S. G., age fifty-six, was admitted to the emergency room on the night of July 29, 1945, with the complaint of severe right quadrant pain of five hours' duration. The previous history revealed pain in the same region accompanied with flatus, belching and dyscrasia to fatty foods for the past six years. However, for the first time since the onset of her illness she had had vomiting and radiation of her pain to the right shoulder.

Examination revealed a middle aged female complaining vigorously of pain in her right abdomen. Her temperature was 99.2°F., blood pressure 148/90, and respirations of 18 per minute. The physical examination revealed the following essential findings: (1) an obese female with tenderness in right upper quadrant, (2) spasm and rigidity of the upper right rectus muscle, and (3) no masses were palpable.

A presumptive diagnosis of biliary colic was entertained and the routine procedure was started. Morphine sulfate and atropine sulfate were given in the usual dosage of $\frac{1}{4}$ and $\frac{1}{150}$ gr., respectively. When no relief was obtained in twenty minutes, aminophyllin was given intravenously with complete cessation of pain in five minutes. The patient was asked to come into the hospital which she refused.

These cases quoted are typical of the other nine cases that were analyzed. They all came into the emergency room with a typical history of biliary colic so that a medical student could recognize it. All these cases had severe pain; this pain radiated to the shoulder or to the right scapula. All had previous histories of gallbladder trouble and some volunteered this diagnosis to the admitting men. In all these cases our routine was to try weak antispasmodics first as nitroglycerine, erythrol tetranitrate and atropine. When no relief was obtained after a suitable length of time, we used central nervous system

narcotics as morphine and pantapone. When the relief was still unobtainable aminophyllin was used. These cases show first that biliary colic was not relieved by the common means and that aminophyllin was far superior to the other drugs used. The rapidity of relief with no toxic symptoms is in itself worthy of report.

The following are examples of the patients seen and treated in the emergency room, followed on the ward and operated upon.

CASE III. Mrs. T. J., age forty-six, was admitted May 30, 1945 to the emergency room complaining of pain in the right upper quadrant. The pain was severe, radiated to the right shoulder and was accompanied with nausea and vomiting. The patient admitted to a previous history of inability to digest fatty foods without suffering from flatus, belching and eructation. This had been present for the past eight years. There was no history of jaundice, diarrhea or previous operative intervention.

On examination an obese middle aged woman was crying in pain, vomiting bile-stained material. Her temperature was 99°F., blood pressure 140/80, respirations 18 per minute. Essential findings were spasm, rigidity of the right upper quadrant with marked tenderness. No masses were palpable.

The patient was put on our established routine for investigation of the drugs concerned. Erythrol tetranitrate was given without relief. This was followed in ten minutes with pantapone gr. $\frac{1}{2}$. With this drug there was some amelioration of symptoms but no relief. Pantapone gr. $\frac{1}{3}$ was then administered which also had no effect after the measured interval of ten minutes. At this time the patient was admitted to the hospital. Here 5 per cent glucose in saline was started. After thirty minutes, aminophyllin was given. The pain had at no time disappeared. After the administration of this drug, the alleviation of pain was complete in five minutes.

On the ward the laboratory work-up showed the urine to be negative for bile, albumin and sugar. The red count had a 4.2 million red cells, 82 per cent hemoglobin, a white count of 11,200 with 68 per cent polymorphonuclears, normal sedimentation rate, negative van den Bergh, icteric index of 10, cholesterol of 90.

The gallbladder series revealed poor function and numerous stones.

While on the ward the patient had return of her pain. In every instance the use of aminophyllin gave relief. The patient was operated upon under pontocaine anesthesia and the gallbladder was removed. It contained many stones of various shapes and sizes. From then on she made an uneventful recovery.

CASE IV. Mrs. I. M., age forty-eight, was admitted March 2, 1945, through the emergency room complaining of knife-like pain in the right upper quadrant radiating to the region between the scapulae. The pain was of ten hours' duration following a meal of macaroni and spaghetti. There was a previous history of dull aching pain for the past two years with idiosyncrasy to fatty foods, and marked belching and flatus. The rest of the history was essentially negative.

Examination revealed a stout Italian woman of middle age groaning in pain. Her temperature was 99.2°F., blood pressure of 142/88, respirations 20 per minute. The conjunctivae showed on icterus. The only positive findings were no examination of the abdomen. Here there was marked rigidity, spasm and tenderness of the right upper rectus. No masses could be palpated.

The patient was tried on the routine of nitroglycerine, atropine and papaverine. The latter again showed some amelioration of symptoms. When the patient still continued to complain, aminophyllin was given intravenously. The relief was immediate in seven minutes.

The patient was then brought to the ward where a work up revealed a urine negative for bile, a white blood count of 12,200 with 68 per cent polymorphonuclears, red count of 92 per cent hemoglobin and 4.8 million red cells, icteric index of 16, negative van den Bergh, normal bleeding and coagulation time, cholesterol of 110. The gallbladder series showed poor function and numerous stones.

While on the ward the patient had to be given aminophyllin at various times for the relief of pain. On March 9, 1945, seven days after admission, the patient was operated upon after suitable preparation. A gallbladder full of stones was removed.

CASE V. Mrs. M. G., age fifty-four. This case is worthy of review since it points out that not every case of cholecystitis is helped by aminophyllin and that morphine and atropine still have their places in our armamentarium.

The patient was admitted with the history of right upper quadrant pain of three weeks' duration. The pain was of the dull aching variety and did not radiate. This pain was never associated with vomiting and nausea. However, during this episode the pains were more severe and incapacitated her even though the history went back for three years. The remainder of the history was negative.

Examination revealed an apprehensive woman of middle age complaining of pain in her right upper quadrant. Temperature and respiration were normal. The blood pressure was 124/74. The only positive findings were in the abdomen. Here we had a positive Murphy, slight spasm and rigidity of the upper rectus.

Laboratory work showed negative urine, a normal blood count, normal bleeding, coagulation time, icteric index, van den Bergh and cholesterol. The gallbladder series showed poor function and poor emptying but no stones. The gastrointestinal series was negative.

This patient was not in distress, consequently aminophyllin was tried first. This did not relieve her aching pain in fifteen minutes. Then morphine was tried with relief. This patient was operated upon. A gallbladder without stones was removed. However, there were numerous pericholecystic adhesions around the gallbladder.

Thus we have a case in which aminophyllin had no value. This illustrates in my mind that its prime use is in colic in which there is associated spasm of the cystic or common ducts.

A résumé of the other ten cases are in order. These cases had symptoms of biliary colic all with typical symptoms and findings. All these patients had relief with aminophyllin after the other common drugs had failed. All showed in varying degrees some relief with papaverine but the pain returned shortly. All were relieved within five minutes after the intravenous administration of aminophyllin. Seven and one-half gr. was the dose used in every case. Among these cases we had one of empyema associated with stones. This patient, a rather elderly male, had no relief with the other antispasmodics or with the narcotics. With aminophyllin he had moderate re-

sults. At operation he was found to have an empyema with stone formation. To explain this we must look to the pathology concerned. This patient had a severe infection with moderate amount of spasm.

CONCLUSIONS

1. Aminophyllin is the drug of choice for the relief of smooth muscle spasm associated with biliary colic.

2. A number of the patients with biliary colic treated in the emergency room were able to leave after a simple intravenous administration of aminophyllin.

3. Aminophyllin, if given slowly, does not produce any toxic symptoms.

4. Papaverine is the second choice in the alleviation of biliary colic.

5. Morphine or its derivatives are poor drugs for the relief of biliary spasm.

6. Aminophyllin has no place in the

armamentarium for the relief of post-operative pain.

7. Since this work shows clearly the value of aminophyllin as an antispasmodic in biliary colic, it is suggested that the surgeon use it directly into the cystic or common ducts following the finding of stones in the gallbladder. This would cause the sediment and small stones to pass into the duodenum.

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EXTERNAL SKELETAL FIXATION OF FRACTURES

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THESE few remarks are not published with the idea of presenting anything new or original but rather to present one man's opinion of this method of treating fractures and to try to explain some of the commonly published criticisms of skeletal pinning of fractures. The treatment of any fracture should be based upon the three cardinal principles of fracture therapy, namely, (1) restoration of all fracture fragments to their true anatomic position, (2) maintenance of that true anatomic position until satisfactory union has occurred, and (3) the preservation of all possible function of joints adjacent to the fracture while it is immobilized.

Restoration of anatomic position of fragments is brought about in almost every instance by traction, countertraction and anatomic manipulation aided in some cases by pressure applied in areas where comminuted bone fragments are located. Traction and countertraction in many cases is difficult due to the movement of soft tissue on bony structures making it impossible to obtain a secure hold on either the distal or proximal fragment. To grasp a leg with one's bare hands to apply traction and countertraction is sometimes impossible, consequently, resulting in a poor reduction or no reduction at all.

Assuming that satisfactory traction, countertraction, manual manipulation, etc., can be accomplished in spite of the elasticity of the soft tissue and a good reduction can be obtained, it is in many instances difficult to maintain this reduction. Particularly in small hospitals where incompetent and insufficient help is employed, to immobilize a well reduced fracture with plaster of paris presents another problem. We have all reduced a fracture of the humerus, tibia, or even a simple Colles

fracture under a fluoroscope and had an orderly to attempt to hold that reduction while a plaster cast was applied and later became very disheartened when we examined a final radiograph. Many fractures which are reduced are difficult to hold manually even by an experienced assistant.

The three cardinal principles of fracture therapy are much more easily accomplished in most cases if the fracture fragments can be manipulated directly and not through the medium of the surrounding soft tissue. Direct contact with the bone is satisfactorily accomplished by placing pins or screws into the bone by some of the methods described by Drs. Roger Anderson, Shaar, Haynes and others. By movement of these pins or screws, traction and other manipulation is made considerably less difficult.

There are many advantages in treating fractures by some of these methods of external fixation. It is far more easy and less hazardous after reduction has been accomplished to place that extremity on a flat table and immobilize the fracture by connecting all of the pins together than to have some inexperienced assistant to steady it for fifteen to twenty minutes while a plaster of Paris cast is applied. The immobilization of a fracture with pins and rods, if properly applied, is also more stable than a plaster of Paris cast because of the fact that a cast sooner or later becomes loose fitting.

External fixation of fractures also simplifies the surgical care of the skin and other soft tissue damage. Compound fractures are a common cause of a large area of soft tissue injury which is difficult to cope with after application of a cast. Even when a small area of soft tissue is involved by the injury and a window is removed from the

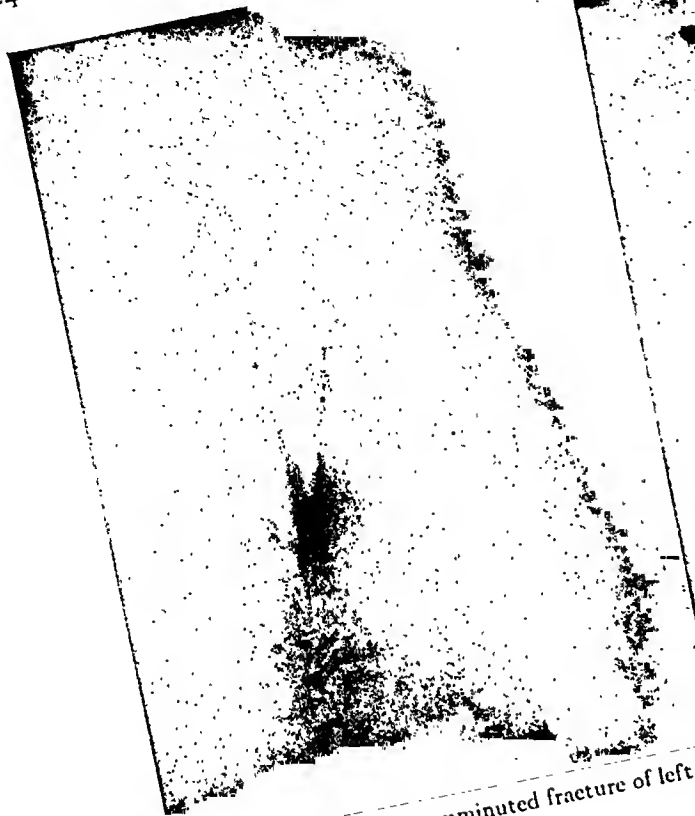


FIG. 1. Case 1. Spiral comminuted fracture of left humerus.



FIG. 2. Case 1. Anteroposterior view after reduction. Notice fracture through tuberosity of head of humerus.

cast through which the wound can be aseptically dressed, the drainage often saturates the cast giving rise to an offensive odor which is unpleasant to the patient and his or her associates and which commonly also leads to an extensive skin eruption which is uncomfortable.

Many orthopedist's answer to this would be to apply the cast and forget the soft tissue damage until the fracture is healed, but we in the country are apparently more sensitive about our body odors. When I, personally, receive such an injury I pray that my doctor will see his way clear to cleanse the exudate from my wounds daily or as often as may be necessary.

Traumatized soft parts accompanied by fractures are more easily treated and daily care is more easily carried out when skeletal-external fixation methods are applied for the treatment of the fracture. There is no offensive odor as there might be from various types of exudate pent up in a cast for

several weeks. The danger of moving the fractured fragments while dressing injured soft tissue is at a minimum, thus lessening the possibility of a non-union or an impairment of good bone repair.

Regardless of the simplicity of immobilization of any fracture of an extremity, some joint, either a wrist, elbow, ankle, or knee, etc., is almost invariably immobilized as well as the fragments themselves. This immobilization of joints for several weeks often times gives rise to stiff joints which in many instances results in more latent grief than the fracture itself. This is particularly true in smaller communities such as the one in which I am located because of the fact that various types of physiotherapy and massage are sadly neglected. The use of external fixation brings to a minimum the number of stiff joints to be placed in the doctor's field of vision at a later date, possibly on some occasion in society where

embarrassment might be brought to bear. This method of treatment of fractures makes possible to some extent the use of what physiotherapy that might be available during the period of immobilization.

We constantly hear and read in the literature of men of renown who criticize skeletal fixation and tell of its horrors and disadvantages. Naturally, as is the case of any method of treatment of anything, there are some disadvantages and poor results but for the most part these disadvantages and poor results are avoidable because the method is mistreated or altered to suit an individual's taste. For instance, the most common criticism placed before the medical profession is the statement that the drilling of pins into a bone gives rise to a portal of entry for infection. On the surface this certainly would seem likely but I have yet to see an infection actually involving bone from the insertion of a stainless steel pin or wire provided it was correctly placed. I have seen many pins which were incorrectly placed about a fracture that was the source of considerable skin and other soft tissue necrosis which gave rise to a large amount of serous drainage. But still in these cases I have not



FIG. 3. Semi-lateral view of Case 1 after reduction.

seen infection truly enter bone nor have I seen a case of pressure necrosis around a pin which did not heal in seventy-two hours after the pin was removed.



FIG. 4. A supracondylar fracture of left humerus in anteroposterior and lateral views described in Case 11.



FIG. 5. Lateral view of Case 11 three weeks after reduction. Anteroposterior view is not shown due to poor detail of radiograph making a photograph impossible.

Placing pins for the external fixation of fractures is like any other surgical procedure, there are a number of "tricks" about it which a surgeon must learn either from his colleagues or from sad experiences if good results are obtained. The pins must be

because here the blood supply is greater and because this usually makes more leverage possible for manipulation and immobilization of the fracture.

Pins must be placed through the soft tissue in a line direct from the point of entrance into the skin to the point of entrance into the cortex of the bone into which the pin is to be placed. In other words, when a pin is placed through the skin and other soft tissue, it must be pushed in a direct line to the bone and not pulled up or down or anterior or posterior before entering the cortex. Such a procedure is the etiology of most of the soft tissue necrosis we see. I have seen instances in which nature would gradually lessen the tension of skin against a pin by a process of advancing necrosis which would completely heal tightly around the pin when the skin had traveled far enough to remove all the tension or pull against it and then the drainage would cease. This

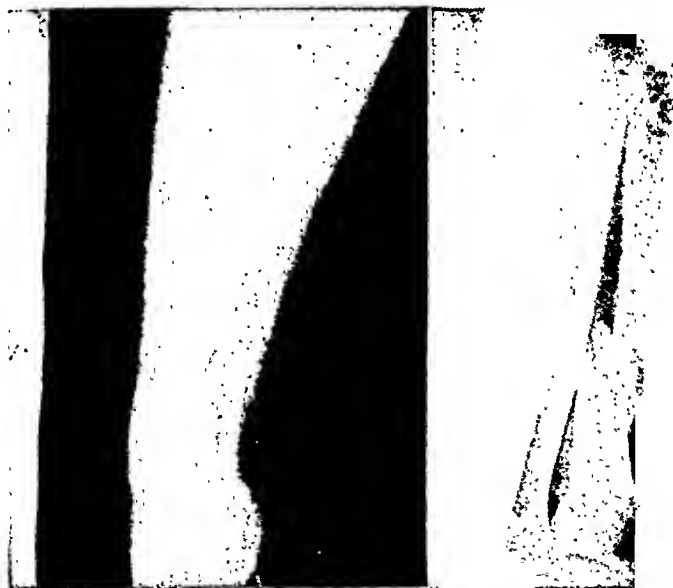


FIG. 6. Compound, comminuted fracture of right radius described in Case 111 before reduction.

placed in specific locations usually near the ends of the long bones regardless of the type of fracture one might be treating. This is what has been described as "precision pinning." Pins are more often placed as near the ends of long bones as possible

slow process gives rise to pain until all the pressure has been removed.

When placing pins into a bone, it is necessary to make allowance for the amount of traction to be applied later to accomplish the reduction of the fracture.

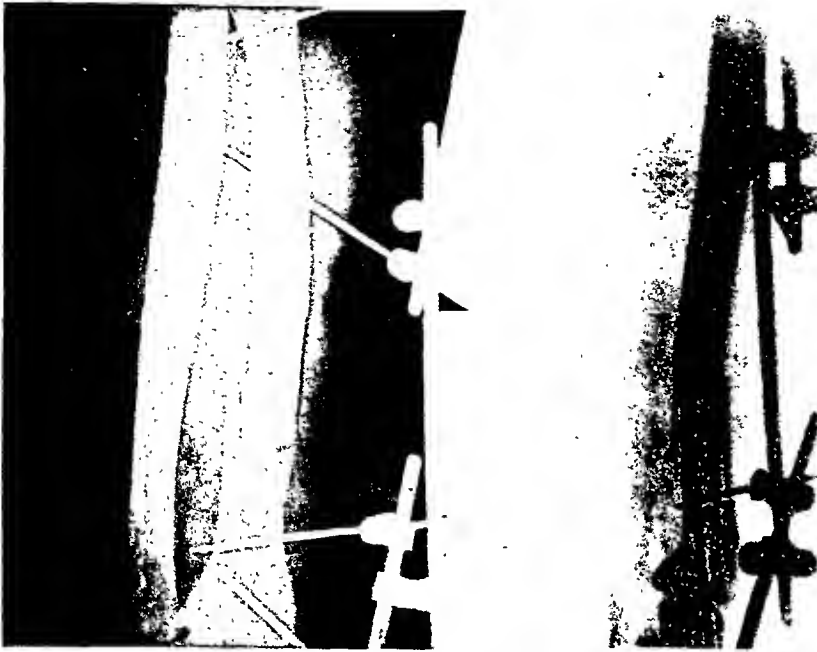


FIG. 7. Lateral and anteroposterior views of Case III after reduction. The poor reduction is probably responsible for the 50 per cent limitation of supination.

Let us take for example a fracture of the mid-shaft of the femur in which there is possibly two or three inches or more overriding of fragments. In such a case, if pins are placed directly above and below the fracture and then enough traction is applied to pull the lower fragment down the necessary two or three inches, the skin between the pins will be under great tension and give rise to severe pain. This can be overcome by placing the pin through the soft tissue to the bone and sliding the pin down over the periosteum for two or three inches toward the fracture before entering the cortex of bone. When this is done there will be no soft tissue under strain and tension after the reduction is accomplished. If this procedure is not carried out, it is better after the reduction to place a sharp pointed knife down along the pin and split the tense skin until all the tension has been overcome. This small cut will usually heal snugly around the pin within a few days.

Another common criticism that we hear is that the pins "work loose" in the bone due to bone necrosis. This is true many times of a through-and-through pin but is rarely true of a half pin if it is drilled into the bone properly. I have noticed that

when removing pins after an adequate period of immobilization that many times a through-and-through pin can be removed merely with the thumb and finger but this



FIG. 8. Intertrochanteric fracture described in Case IV before reduction.

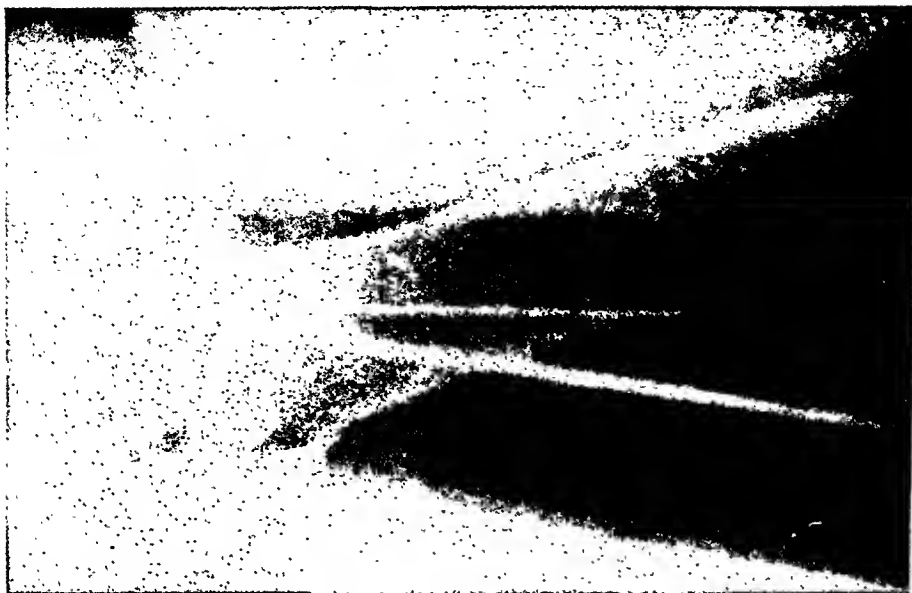


FIG. 9. Lateral view of Case IV after reduction and introduction of first pin from shaft of femur through the fracture into head.

is not true of a pin that has been placed only through both cortices of bone and has not protruded on through the skin and soft tissue of the opposite side. Naturally, if a pin becomes loose it must be due to a

necrosis of bone and this is usually due to an improper method by which the pin is placed into the bone. When a pin is placed into a bone with a hand chuck at a low rate of speed it will remain tight in that bone for an infinite amount of time. But if a highly geared drill is used and the pin is turned at a rapid rate of speed, a thermal necrosis will be caused resulting in a loose pin at a later date.

Electrolysis has been said to be an etiological factor to "loose pins" but this has never been proven to my own satisfaction. Electrolysis is said to be a process by which a metal is decomposed by a current flowing between two different metals through a salt solution. In the first place, there is only one type of metal involved and, secondly, I have never seen a stainless steel pin removed from a bone which grossly demonstrated any visible signs of chemical decomposition. So it is my meager opinion that electrolysis as a cause of bone necrosis is more theory than fact.

Another seemingly unimportant "trick" to this method of treatment of fractures is the application of a dressing to the pins which actually is the all important thing in the prevention of "draining pins." If the skin and soft tissue can not move around or

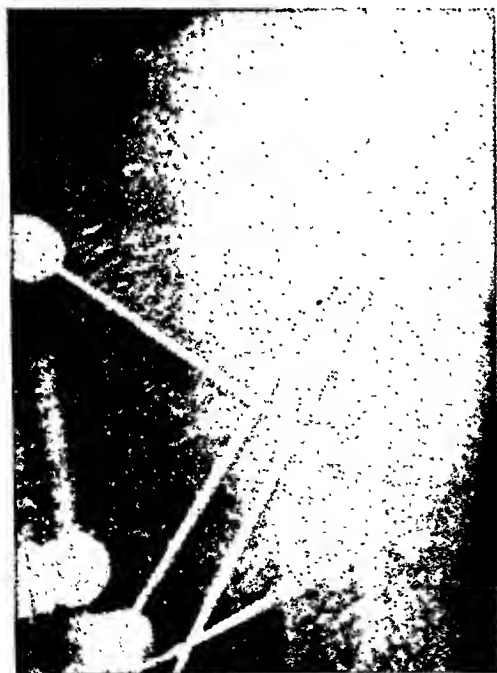


FIG. 10. Anteroposterior view of Case IV after introduction of pins through the fracture into the head of the femur and the half pin unit below the fracture site.



FIG. 11. Anteroposterior and lateral views of Case v; fracture of tibia in middle third and of fibula in lower third.

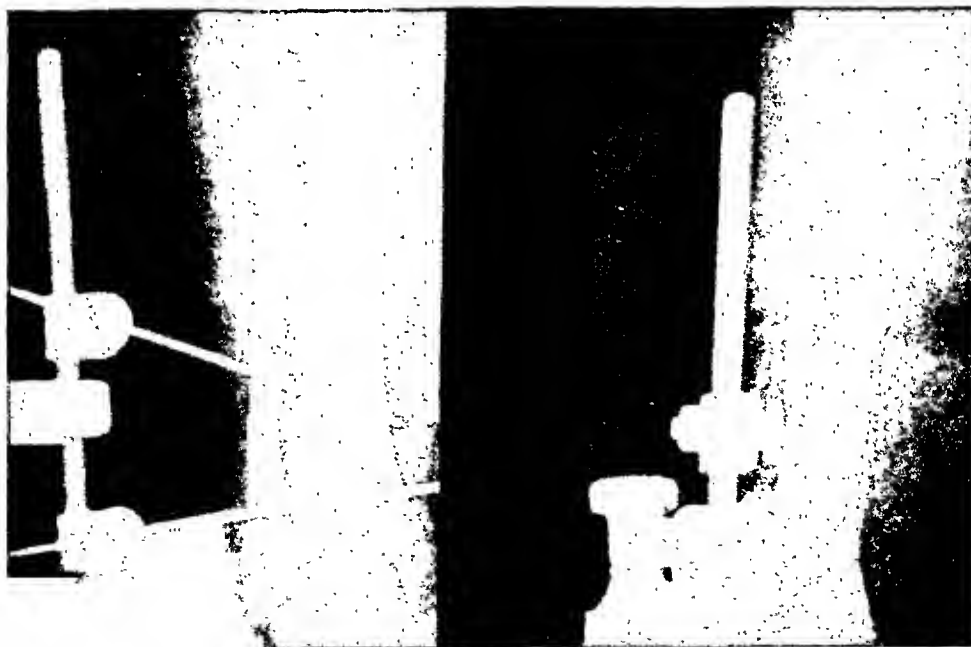


FIG. 12. Anteroposterior and lateral views of Case v after reduction.

against a pin, there will be no drainage, assuming, of course, that the technic of placing the pins into position has been aseptic. Consequently, a dressing must in some manner be placed around the pin compressing the soft tissue against the underlying bone structure. In a recent article by Dr. E. H. Wilson the statement is made that "in the femur the upper pin almost always causes pain because of the

amount of motion necessary in the muscles of that region while active." This statement is perfectly true but I have found that a great percentage of "painful pins" in that region can be overcome by the use of proper pin sites and by a properly applied dressing. This is rather difficult to overcome in the extremely obese patient but a "painful pin" and drainage around that pin will assure the surgeon that there has been enough



FIG. 13. Anteroposterior and lateral views of Case vi showing compound, comminuted fracture in lower third of tibia and fibula before reduction.

active motion of the hip joint that the worry about a later stiff hip joint is nil.

Much of the criticism of this method of fracture treatment that we commonly hear has its origin from surgeons who have treated two or three fractures before they had taken the time and trouble to master the principles of the technic and this criticism is certainly unjust. The use of skeletal pinning and external fixation is a study in itself. Pins cannot be "thrown" into a bone in just any location, connected together by rods, and a good result be anticipated. I recently attended a meeting in which an Army dental surgeon highly criticized the pinning of mandible fractures because "the pins came loose and left unsightly scars on the face." In that large Army Hospital only three such cases had been treated by this method and when photographs were exhibited, it was obvious that the poor results were due to the fact that the operator had no conception whatsoever of the principles of the technic he had attempted to employ. Many men are obtaining excellent results in the treatment of mandible fractures by the proper technic.

I have commonly heard the statement "if you want non-union, use skeletal pin-

ning." In several instances I have had an opportunity to examine the radiographs of these non-unions only to find in almost every instance the fragments had been fixed in such a manner that there was at least one-fourth to one-half an inch space between the fragments. Now any physician with any understanding of histology and pathology should realize that nature has unfortunately not yet given birth to a fibrocyte or osteoblast that could jump such a gap. As has been stated before "this technic is a method of the treatment of fractures by contact and not by traction."

Skeletal pinning and external fixation is not the final word for treatment of every fracture and there are undoubtedly many instances in which it is used where a more simple method would suffice. But I do believe that if the principles of this technic are mastered before it is put to practice, that it will solve many of our fracture problems.

I have chosen several cases to present various types of fractures which have successfully been treated by skeletal pinning and external fixation which treated by any other method would have required longer

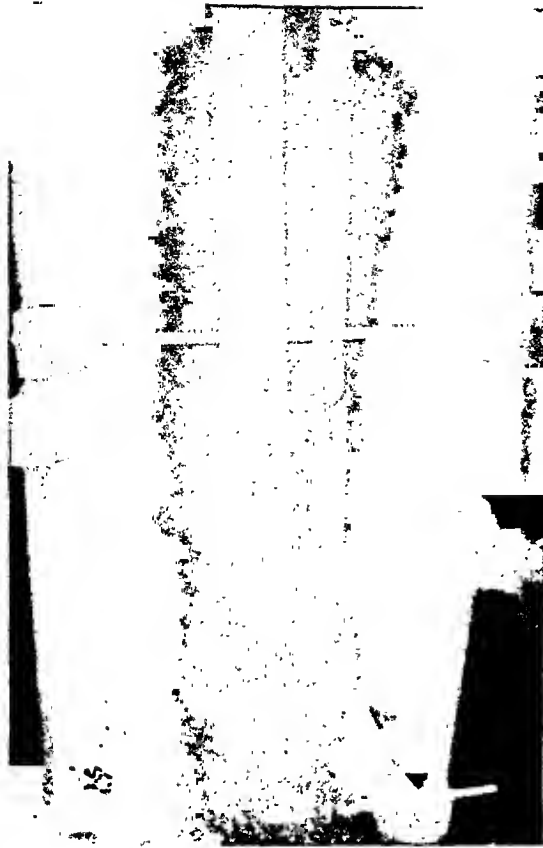


FIG. 14. Anteroposterior view of Case VI after reduction.



FIG. 15. Lateral view of Case VI after reduction.

periods of hospitalization or more discomfort to the patient.

CASE 1. A white male, age fifty-four years, fell on the ice on Christmas day, 1944, and received a spiral fracture of the upper third of the left humerus and a comminuted fracture of the head of the same humerus, as shown in Figure 1. There was considerable hemorrhage and damage to the surrounding soft tissue. Under ether anesthesia and with difficulty, two pins were placed into the comminuted head obtaining a firm hold on the upper fragment. A half pin unit was placed in the posterior surface of the distal end of the distal fragment and a satisfactory reduction obtained by a self aligning splint after which the two units were connected by a long curved rod as shown in Figures 2 and 3. This patient had considerable pain for about three weeks apparently due to hemorrhage and soft tissue damage but not at the pin sites. After this time he was able to get about 80 to 85 degrees abduction of the shoulder and almost full range flexion and extension of the elbow and was able to carry out his usual duties in a bank. On February 20,

1945, eight weeks after reduction, the equipment was removed and a good solid union was found. The patient at present has an almost normally functioning shoulder and elbow.

CASE 11. A white male, age seven years, fell off a porch and received a supracondylar fracture of the left elbow as shown in Figure 4. When first seen there was considerable edema of the soft tissue at the fracture site and "skin blebs" had begun to form. This would have been a poor case to place in marked flexion and immobilization in this position with plaster of Paris to run the risk of a Volkman's paralysis. A one-half pin unit was placed in the superior humerus, care being taken to avoid damage to the epiphysis. One through-and-through pin and a half pin was placed in the olecranon. The reduction shown in Figure 5 was obtained and rods connected the units both on the medial and lateral sides of the elbow fixing the elbow joint in semi-flexion. The patient had very little discomfort and it was possible to make daily observations of the skin and soft tissue near the elbow until the edema had subsided. The patient was able to play as usual and the equipment was removed during the fifth postoperative week. He has a



FIG. 16. Anteroposterior and lateral views of Case VI sixteen weeks after accident and after removal of pins and other equipment.

final result which would be considered a normal joint from the functional standpoint.

CASE III. A white male, age fifty-two years, received a compound, comminuted fracture of the right radius as a result of a dynamite explosion in a coal mine. (Fig. 6.) After cleansing the wound and carrying out a débridement, sulfanilamide powder was placed into the wound and it was closed without drainage. A half pin unit was placed through the distal radius and one through the superior radius and the reduction seen in Figure 7 was obtained. The compound wound healed by primary intention. The patient had an uneventful convalescence with the exception of the superior pin which had been improperly placed, being lateral instead of medial to the flexor carpi radialis longus muscle, which caused pain and some drainage which had subsided before the equipment was removed the seventh postoperative week. At present, eleven weeks postoperatively, the patient has an arm with 100 per cent pronation and only about 50 per cent supination which will improve to some extent with time and use and which was due to a rather poor reduction that should have been improved upon in the beginning.

CASE IV. A white female, age seventy-one years, fell and received an intertrochanteric fracture of the right hip as shown in Figure 8 and who five years prior had received a similar fracture of the left hip which was treated by a

Buck's extension with a poor result. On admission into the hospital the patient had a blood sugar of 220 mg. per 100 cc. of blood besides an auricular fibrillation. Two weeks were required to control the fibrillation and the diabetes during which time the injured leg was placed in a Thomas splint. The first day of the third week, under ether anesthesia, a reduction was obtained by aid of a fracture table. Parallel $\frac{1}{32}$ by 10 inch pins were placed from low on the shaft through the fracture into the neck and head of the femur, care being taken by a lateral radiograph that the pins were in correct position along the anterior medial cortex of the neck as shown in Figure 9. A half pin unit was placed in the shaft below the fracture and all four pins connected by two rods as shown in Figure 11. Time was spent in applying a dressing which firmly compressed the skin and soft tissue around the pin sites. The patient was in a wheel chair the second postoperative day and daily thereafter. The thigh was fully flexed on the abdomen at random. The equipment was removed the sixteenth week and a satisfactory union and good functional results obtained. During the period of immobilization the pin sites were dressed only four times and each time the pin sites were found clean with no drainage, undoubtedly in this satisfactory condition due to the pressure dressing.

CASE V. A white female, age forty-one years, fell off a ladder and received a spiral

fracture of the middle third of the left tibia and a fracture of the lower third of the left fibula as shown in Figure 11. The leg was first put in traction and a padded plaster of Paris cast was applied from the upper thigh to the toes. Three days later a radiograph taken revealed that the lower fragment was rotated and the fragments were overlapping about two inches. One through-and-through pin and a half pin was placed in the upper tibia and the same in the lower tibia. A satisfactory reduction was accomplished. The pins were connected with rods as shown in Figure 12 and the fracture was left immobilized for ten weeks. At that time a radiograph demonstrated adequate callous formation and the pins were removed and the fracture was found to be solid to manual manipulation. Weight bearing was permitted in sixteen weeks from the time of the injury. At present the patient has a normal functioning leg.

CASE VI. A white female, age thirty-eight years, received a badly compound, comminuted fracture of the left ankle in an automobile accident as shown in Figure 13. There is also a fracture through the internal malleolus and the fibula simulating a Pott's fracture. The soft tissue wound was débrided after the usual aseptic preparation. The protruding upper fragment was manipulated as near as possible into place and the wound was filled with sulfanilamide crystals and closed without drainage. Two through-and-through pins were placed in the upper fragment, one at the upper tibia and one just above the fracture site, and another through-and-through pin was placed in the os calcis. With the aid of a self aligning splint the fracture was satisfactorily reduced as shown in Figures 14 and 15. A posterior plaster of Paris mold was applied from the knee to the toes to act as a support to prevent any posterior displacement and also to prevent a "foot drop." The posterior cast was removed in eight weeks. There was some purulent drain-

age from the medial side of the pin just above the fracture which subsided in forty-eight hours after the sutured area was opened to allow adequate drainage from the infection caused by the compound fracture. This infection had subsided and drainage stopped within two weeks with the aid of chemotherapy. The pins were removed sixteen weeks following the injury and a solid union was found as shown in Figure 16. This radiograph also reveals considerable osteoporosis undoubtedly due chiefly to the infection at the fracture site. At present the patient has a good functional ankle joint although there is still some weakness probably caused by the osteoporosis. At the present, twenty-two weeks after injury, she bears full weight on the foot but wears a high top leather shoe.

There are many other fractures which are satisfactorily treated with this method.

SUMMARY

1. Skeletal pinning and external fixation has been discussed. The general principles with this method are the same as for any other method of fracture therapy and must be respected and not forgotten.
2. Some of the advantages and disadvantages of skeletal pinning and external fixation have been discussed.
3. Common criticisms have been discussed and explained.
4. Cases for various types of fractures treated by skeletal pinning and external fixation have been presented.

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CONSERVATIVE TREATMENT OF THYROTOXICOSIS WITH THIOURACIL

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FOLLOWING Astwood's¹ introduction of thiouracil in the treatment of thyrotoxicosis, numerous clinical reports appeared on this subject, dealing mostly with the preoperative employment of the drug. It seemed desirable to supplement the reported observations by a study of the usefulness of thiouracil* in situations which make a conservative treatment of hyperthyroidism the method of choice.

MATERIAL

With the kind collaboration of my colleagues at St. Elizabeth Hospital a group of twenty-one patients was selected for the study. Five of the patients had had one or more subtotal thyroidectomies and refused to undergo a second operation. Of the remaining sixteen, thyroidectomy was contraindicated in three on account of old age (over seventy-three years) accompanied by far advanced senile changes in the cardiorenal system; six had signs of heart failure caused by valvular lesions poorly responding to the customary therapy; three had coronary sclerosis; two were suffering from malignant hypertension, one had cirrhosis of the liver with recurrent ascites and one had diabetes and hypertension.

The age of the patients ranged from thirty-two to seventy-six; twenty were females and one was male. Twelve patients had a diffuse, hyperplastic type of goiter, four had a toxic adenoma and five had recurrent hyperthyroidism after operation.

Seventeen patients had had hyperthyroidism for more than two years; two patients had had signs and symptoms of

thyrotoxicosis for over one year and two for over eight months.

The basal metabolic rate at the onset of treatment with thiouracil ranged from 32 to 68 with the average of 41.

Of the twenty-one patients, three had been previously treated with Lugol's solution but an interval of several months elapsed between cessation of administration of iodine and the start of thiouracil therapy.

METHOD OF TREATMENT

Two cases required hospitalization on account of concomitant diseases while in all others the thiouracil therapy was ambulatory. Patients were allowed to continue their usual activities and no special dietary régime was prescribed, the diabetic patient being the only exception. In order to obtain clear cut results of the thiouracil treatment, all other medications were avoided with exception of an occasional laxative. All patients were given a complete physical examination before the treatment was instituted. Blood counts, including the differential count, were repeated in course of the thiouracil treatment at seven to ten day-intervals and the basal metabolic rate was determined every two or three weeks.

In the early stages of the investigation the usual initial dose was 1 tablet, containing 0.2 Gm. of thiouracil, three times daily after meals. On repeated occasions the patients described certain symptoms of intolerance of the drug, such as nausea, dizziness, tremor and tachycardia. Although the symptoms were insignificant, they suggested a new mode of administration of the drug; the first three days the patients were given only one tablet after breakfast, the next three days one tablet

* Generously supplied by Eli Lilly & Co., Indianapolis, Ind.

after breakfast and lunch and after the first six days one tablet was to be taken three times a day after meals. Absence of untoward symptoms corroborated the hypothesis that a gradual increase of the total daily dose gives the organism sufficient time to develop tolerance of the drug. It must be stressed that this gradual increase of the daily dose proved beneficial as far as the avoidance of the initial symptoms of intolerance was concerned; it was unable, however, to prevent certain more serious toxic side effects.

After the dose of 0.2 Gm. three times a day had been reached, it was continued until there was a marked symptomatic improvement and the basal metabolic rate dropped to about $+15$, after which time the dose was reduced to 1 tablet after breakfast and supper. As soon as the basal metabolic rate reached the normal level, the dose was reduced to one tablet after breakfast only. If the rate did not show any tendency to rise, the maintenance dose was reduced after two or three weeks to one-half to one tablet once a day. In no less than eight cases out of twenty-one it was possible to further reduce the dose to one tablet on Monday, Wednesday and Friday only.

On repeated occasions it became necessary to increase the dose temporarily when the basal metabolic rate rose, usually due to an emotional strain, only to be reduced again when the rate dropped to the normal level. In other words, a continuous close observation was required to adjust the dose to the patient's requirements.

Fifteen patients had received the drug for as long as 5 months and the remaining six for a shorter period of time. If the therapy was discontinued, a relapse of the thyrotoxicosis occurred within two or three weeks. In not a single case was it possible to produce a sustained remission after cessation of the therapy.

RESULTS

Out of twenty-one patients the administration of thiouracil had to be discontinued

in two soon after it was instituted on account of toxic side effects. In all others a full control of objective signs and subjective symptoms of hyperthyroidism was obtained. The basal metabolic rate showed a progressive fall until it declined to the normal level within two and half to six weeks after the treatment had begun. Gain in weight was recorded in nine patients. All made the unsolicited remark concerning the return of the sensation of well being. A high degree of amelioration in reversible cardiac sequelae of hyperthyroidism, improvement in appetite, cessation of diarrhea and diminution or disappearance of tremor were noticed in all patients. The effect on exophthalmos was slight in some cases, more marked in others. A certain degree of exophthalmos persisted in spite of prolonged thiouracil treatment.

As to the local condition, the changes in the thyroid gland were variable. During the first few weeks of treatment the thyroid gland in a majority of cases showed a tendency to increase in size and become softer, especially in patients with a diffuse, parenchymatous goiter, while the toxic adenoma seemed to become firmer but not larger.

After the first few weeks the gland became essentially normal in size only in two patients with a diffuse goiter while in the remaining cases the size and consistency of the goiter were approximately the same as before the treatment. In patients with a toxic adenoma the goiter after the first few weeks did not show any appreciable changes in size or consistency. The recurrent goiter remained unchanged in two patients while in the other three it increased in size.

REACTIONS

Slight reactions in form of nausea, tremor, dizziness and cardiac palpitations were noticed within the first two days after the institution of treatment in six cases out of twenty-one. However, they were insignificant, did not warrant cessa-

tion of treatment and subsided within a short time.

In two cases the toxic side effects necessitated immediate interruption of the treatment with thiouracil. For the sake of brevity only the most essential data pertaining to these cases shall be mentioned.

One patient was a woman, aged seventy-two, with a toxic adenoma and hypertensive heart disease. Her basal metabolic rate at the time of admission to the hospital was +53. She was complaining of cardiac palpitations, dyspnea and choking sensation in the throat. After she had taken nine thiouracil tablets within three days, she developed drowsiness, profuse perspiration, loss of appetite, nausea, vomiting and epigastric distress. Her pupils were contracted and responded poorly to light and accommodation, her respiration became labored and the pulse slow and weak. Administration of thiouracil was discontinued and the patient recovered within two days following the use of stimulants and supportive treatment.

The second patient who did not tolerate thiouracil was a woman, age thirty-five, with a toxic adenoma and a basal metabolic rate of 36. She had been taking thiouracil, 1 tablet three times a day, for twenty days when she suddenly experienced a choking sensation and noticed considerable swelling of her tongue. The symptoms subsided spontaneously within a few hours but returned after the intake of another thiouracil tablet.

Other toxic side effects described in the literature^{2,3} such as diarrhea, rashes, fever, jaundice, pruritus, purpura, articular and muscular pains and swelling of salivary glands did not occur in any of the twenty-one patients.

As to the blood changes, no significant drop in the white cell count has been encountered and agranulocytosis fortunately has not been observed. However, six patients developed a relative lymphocytosis, not exceeding 45 per cent, after the first three weeks of thiouracil treatment. This finding alone was not deemed of sufficient

significance to warrant cessation of treatment, and periodic blood examinations showed that the neutropenia had a tendency to remain stationary without any inclination to increase. Nevertheless, a restitution of a normal differential blood count was considered desirable. In place of drugs recommended by other authors^{4,5} for the treatment of agranulocytosis and granulocytopenia, such as ascorbic acid, pyridoxine, liver extract, pentnucleotide and penicillin, foreign protein injections, using some of the commercial preparations, have been tried with surprisingly good results. After six to ten injections, given every third day, in addition to sizeable increase of the total number of leukocytes, a restitution of the normal differential count was noted. Following this observation a standard procedure was adopted, whereby concurrently with administration of thiouracil the patient was given from the very start one or two hypodermic injections of foreign protein a week, according to the intensity, if any, of granulocytopenia.

COMMENTS

A review of the thiouracil treatment of twenty-one patients with thyrotoxicosis shows that the therapy failed in none of the patients with the exception of two who apparently did not tolerate the drug. On the other hand, no permanent cure has been obtained and the amelioration or disappearance of hyperthyroidism depended on continuation of the treatment. Further observations are required to determine whether such a continuous administration of thiouracil is innocuous and does not produce harmful effects which may escape detection within a relatively short period of treatment. The discussion of usefulness of thiouracil in preoperative treatment of patients with thyrotoxicosis is beyond the scope of this paper. If a thyroidectomy is contraindicated, thiouracil seems to be the drug of choice.

A gradual increase in the daily dose until the customary amount of 0.6 Gm. has been

reached seems to limit the number and intensity of toxic side effects.

If blood examination reveals granulocytopenia, it appears that the latter can be combatted successfully with foreign protein injections. However, according to the latest reports, large doses of penicillin should be given if agranulocytosis develops.

In view of the fact that periodic blood examinations at frequent intervals are essential, the patient should never be given more than one week's supply of thiouracil and the prescriptions should not be refillable.

It is hoped that ultimately a substance related to thiouracil or an entirely different chemical substance will be found, which will have a similar beneficial influence on thyrotoxicosis but without frequent toxic side effects.

SUMMARY

1. Thiouracil proved a highly efficient drug in the treatment of nineteen patients with thyrotoxicosis in whom a thyroidectomy was contraindicated. Two other patients with similar conditions did not tolerate the drug and the treatment had to be discontinued.

2. Cessation of administration of thiouracil is apt to be followed by a relapse of hyperthyroidism.

3. Untoward reactions can be lessened in frequency and intensity by increasing the daily dose gradually until the standard

dose of 1 thiouracil tablet three times a day has been reached.

4. Foreign protein injections proved efficacious in combatting granulocytopenia and relative lymphocytosis. They may be given for prophylactic purposes simultaneously with thiouracil treatment before any changes in the differential blood count occur.

5. Periodic blood examinations and determination of the basal metabolic rate and also repeated physical examinations are *conditio sine qua non* when thiouracil is administered. For this reason the patients should never be given more than one week's supply of thiouracil and the prescription should be marked "not refillable."

6. The maintenance dose should be the smallest amount of thiouracil able to keep the basal metabolic rate at a satisfactory level. This dose may be as small as one tablet three times a week.

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THE MANAGEMENT OF CARCINOMA OF THE COLON IN A SMALL GENERAL HOSPITAL*

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MOST articles dealing with carcinoma of the colon and rectum have been published by men working in the larger general hospital, the university hospitals or some of the large private clinics. It occurred to us that it might be interesting to these men, as well as to men working in the smaller hospitals to know of the experience of one working in a rather small general hospital. With this thought in mind, a review of the cases of carcinoma of the colon and rectum managed by us from June 1, 1943, through October 31, 1945, was undertaken, and the findings of this review constitute the basis for this report.

This hospital is listed as having approximately ninety-three beds, is general in type, but attempts to exclude patients with contagious diseases, pulmonary tuberculosis and psychiatric disorders. It is operated, not for profit, under a Board of Directors appointed by the church, and rents office space in its main building to a small group of physicians who practice as a group clinic. Other physicians in the city use the hospital's facilities, but the staff is organized and departmentalized, and only those physicians holding staff appointments are offered these privileges.

The surgery of the clinic group is performed by a surgical team whose personnel is kept fairly constant. The department of anesthesia is under a full time physician anesthesiologist, who is also in charge of all intravenous fluids, blood plasma, and blood transfusions. The laboratory and x-ray departments are under the part time direction of a competent pathologist and roentgenologist, respectively. These organizational details

are being presented in order to furnish a background for this report, whose primary purpose is to tell of the experiences encountered during the management of these lesions in a small general hospital, and not to present new technics or methods of treatment.

The incidence of carcinoma of the colon may be on the increase. If one becomes interested in this lesion and starts searching for it, he cannot but be impressed by the increasing number which he finds. The importance of the rectal and proctoscopic examination cannot be too strongly emphasized. The aid of an energetic, interested roentgenologist, who is willing to do repeated examinations, is most helpful.

It has seemed to us that most physicians have assumed too pessimistic an attitude toward carcinoma of the colon and rectum. This may be due to the fact that in small centers, the diagnosis of the lesion has been overlooked until distant metastases have occurred and curative treatment out of the question. Surgery has been regarded as an indifferent measure, and due to its high mortality and morbidity, condemned by some. The palliative colostomy patient has presented a sad picture which has tended to discourage the patient, his relatives and his physician, and has played its part in the production of the pessimistic attitude held toward this disease. In one sense of the word this class of patient should serve as a reproof to the medical attendants for not having established the diagnosis earlier.

The operative mortality of these lesions has been lowered considerably in recent years and the late results improved.

* From the Surgical Service of Welborn Memorial Baptist Hospital.

This has been due in a large measure to improvements in anesthesia, in the use of blood transfusions and the sulfonamides. The morbidity has been lowered, the hospital days decreased, and the incidence of multiple stage procedures diminished.

TABLE I

LOCATION OF MALIGNANT LESIONS OF THE COLON

Cecum.....	2
Ascending colon.....	5
Hepatic flexure.....	2
Transverse colon.....	1
Descending colon.....	2
Sigmoid colon.....	7
Rectosigmoid.....	8
Rectum.....	12
Total.....	39

During the twenty-nine month-period under study, there were thirty-nine patients treated by us for malignant disease of the colon and rectum. There were eighteen males and twenty-one females. The average age was fifty-seven. Thirty seven were white and two colored. Figure 1 depicts the location of these lesions, and Table I represents a more detailed breakdown of the location of the tumor.

The diagnosis in three cases was established by x-ray alone, but one of these had a palpable mass in the region of the descending colon, which served to confirm the x-ray diagnosis. In the remaining thirty-six cases the diagnosis was established by operation, sigmoidoscopy and biopsy, or by necropsy.

Twenty-six of the thirty-nine patients were operated upon; the remaining thirteen patients either refused operation or had such extensive disease that surgery was considered hopeless. Of the twenty-six patients coming to surgery, sixteen were considered to have resectable lesions and ten to have so-called non-resectable lesions. In the latter group some had resection of the lesion, but either local or distant metastases made the operation palliative, rather than curative in nature.

Table II depicts the location of the lesion, operative procedure, and hospital mortality of the patients on whom operation was performed. As noted above,

TABLE II
LOCATION OF LESION, NUMBER OF CASES, OPERATIVE PROCEDURE, AND HOSPITAL MORTALITY OF PATIENTS COMING TO OPERATION

Location of Lesion	No. of Cases	Operative Procedure	Hospital Mortality
Rectum and rectosigmoid....	6	One-stage combined Abdomino-perineal resection	0
Rectosigmoid...	4	(2) Ant. resection-compl. loop colostomy (1) Palliative loop colostomy; biopsy mesentery (1) Exploration only; biopsy	1
Sigmoid.....	6	(1) Palliative ant. resection; metastases (2) Mikulicz exteriorizations (1) Exploration, palliative trans. loop colostomy (1) Exploration only; biopsy (1) Loop colostomy obstruction; anterior resection	0
Descending colon.....	2	(1) Trans. loop colostomy; palliative (1) Loop colostomy for obstruction palliative ant. resection	0
Hepatic flexure	2	(1) Cecostomy for obstruction; rt. hemicolectomy; ileotransverse colostomy (1) Cecostomy for obstruction; Lahey-Mikulicz right hemicolectomy	0
Ascending colon	4	(1) Exploration only; metastases (1) Rt. hemicolectomy—Lahey-Mikulicz (1) Rt. hemicolectomy; ileotransverse colostomy (1) First stage ileotransverse colostomy	0
Cecum.....	2	(1) Rt. hemicolectomy; ileotransverse colostomy (1) Palliative ileotransverse colostomy	1
Total.....	26		2

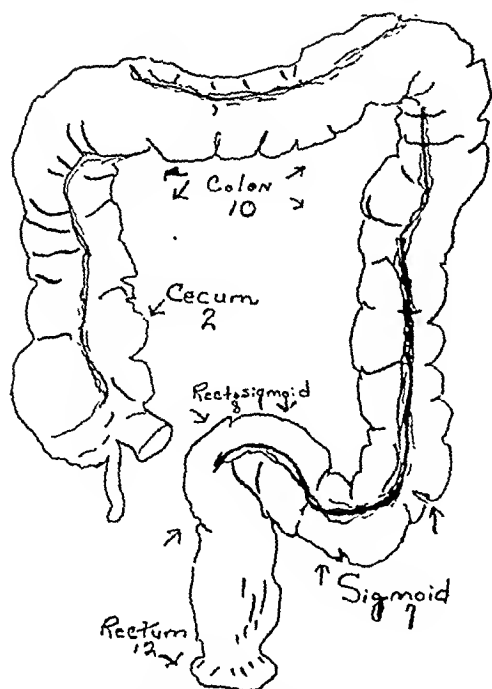


FIG. 1. Location of the malignant growths of the colon and rectum herein reported.

sixteen of these patients had resectable lesions, and in this group the resections were undertaken with the thought of curing the patients. There were no deaths in this group. The patients having palliative procedures usually had extensive local or distant metastases with or without obstruction. Two of them had perforated lesions surrounded by abscess cavities. There were two deaths in this group. They will be discussed later.

Thirteen, or 50 per cent of the patients in the operative group had varying degrees of obstruction, and in all but two cases the point of obstruction was in the left colon. When operative decompression was indicated, it was accomplished through a short, upper, right transverse incision, usually with exploration of the abdomen by palpation and transverse loop colostomy. Two patients had acute obstruction due to carcinomas at the hepatic flexure. They were operated upon through a right transverse incision, and were decompressed by mobilizing the distended cecum and drawing a generous portion of it through a stab wound in the right

lower quadrant. Immediate temporary catheter colostomy was performed. The cecum did not retract within the peritoneal cavity.

One patient with an acute obstruction died without operation. He was treated by conservative measures for three days without relief. At autopsy he was found to have a generalized peritonitis from a perforated cecum induced by an obstructing carcinoma of the sigmoid colon. The ileocecal valve appeared to be competent. This probably interfered with the colon decompressing itself by means of regurgitating into the small bowel.

Palliative colostomies were performed as a last resort for uncomfortable, acutely distended patients. It is surprising, at times, how comfortable an inoperable, distended patient can be made with a liquid diet, intermittent gastric suction and opiates. The colon may become irritable in the presence of a remaining lesion, and in such circumstances a colostomy will discharge copiously and make the nursing care difficult. Such experiences as these have brought unjustified criticism on the permanent "curative," colostomy, which behaves in a much better manner.

One patient having an ileotransverse colostomy as the first stage for a growth in the ascending colon, refused to submit to the second stage and as a result died from carcinoma. Latterly, we have done exteriorization procedures or one-stage resections at this level, with a preference for the latter. Primary, open anastomosis, has been used at all times, usually with complementary colostomy, but recently without this possible safeguard. In its absence the anal sphincter is dilated widely in order that flatus may easily escape.

There were two hospital deaths in this series. One occurred in a fifty-seven year old colored female with a perforating carcinoma of the cecum, localized abscess formation, direct extension of the growth to the terminal ileum, emaciation and secondary anemia. The operative pro-

cedure consisted of palliative ileotransverse colostomy and drainage of the abscess. The patient died in shock the afternoon of the day of operation. No necropsy was performed. The second death was that of a thirty-eight year old white male with an obstructing carcinoma of the rectosigmoid, extensive liver metastases, jaundice and cachexia. A palliative transverse loop colostomy was done, and seemed to make the patient's remaining days more comfortable. He died on the ninth day following operation.

The mortality and morbidity rates in patients undergoing surgery for malignant diseases of the colon remain high. These rates are gradually being lowered by better preoperative preparation of the patient with the sulfonamides, blood transfusions and the vitamins. These patients should not be operated upon unless the facilities, including trained personnel, exist for their thorough preoperative preparation. The conduct of the operation itself bears an important relationship to the morbidity and mortality and should be in the hands of a trained team. This team should have an anesthetist who is familiar with some of the problems likely to be

encountered, and who is willing to devote hours, if necessary, to the proper conduct of the anesthesia, and its related problems of fluid and blood replacement and stimulation. The surgeon should be assisted by an adequate number of trained personnel. Fine grades of suture materials and properly designed instruments also play an important part in determining the success of the operation.

SUMMARY

1. Some experiences encountered in the treatment of carcinoma of the colon and rectum in a small hospital are reported.
2. Thirty-nine patients with neoplastic disease of the colon and rectum were treated during the twenty-nine-month period studied.
3. Twenty-six of the thirty-nine patients were operated upon. Sixteen of these were considered to have resectable lesions and ten non-resectable lesions. There were two hospital deaths in the patients operated upon.
4. Carcinoma of the colon and rectum can be managed successfully in the small general hospital if a trained surgical team is available.



VAGINOPLASTY

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VAGINOPLASTY is the art of plastic repair of herniations of the urethra, bladder and rectum into the vaginal sheath.

Symptoms in these herniations are urinary disturbances, stress incontinence, the presence of a protruding vaginal mass and a sense of "things dropping out." Relief of symptoms follows effective repair. Successful planning of the repair rests on first hand acquaintance with the structure of the tissues involved. These tissues are the muscles with their investing fascia, which form the pelvic floor,—the levator ani and coccygei. (Fig. 1.)

The vaginal slit is a distensible canal which forms a weak spot in the pelvic floor. As long as the floor is healthy and intact, all is well. If the floor is weak from underdevelopment or disease, or is damaged by injury or infection, herniation develops. In that event we are faced with: a condition of herniation; a problem of effective repair; and a procedure—(a) removal of sac (vaginal wall), (b) replacement of contents (urethra, bladder, rectum), and (c) restoration of supporting wall (pelvic floor).

Urethrocele. (Herniation of the Urethra): The urethra begins at the most dependent part of the bladder and follows a slightly curved downward and forward course as far as the symphysis and then tilts upward to end at the meatus. (Fig. 2.) This upward tilt is very important in the problem of repair. The sphincter muscle of the urethra lies in a slit-like pouch formed by the layers of fascia attached to the inner sides of the pubic arch. It surrounds the entire membranous portion of the urethra.

In urethral herniation we have a three-fold condition: urethrocele, damaged sphincter and alteration in direction of the canal. (Fig. 3.)

The problem is effective repair of the urethra. Bladder control will not be established if a damaged urethra is left unrepaired.

The procedure comprises removal of the sac by excision, repair and replacement of the urethra by para-urethral fixation with two rows of mattress sutures, the deep row repairing the sphincter and the outer row bringing the fascia together, and the restoration of the upward tilt of the part beneath the symphysis.

The last step may be done in one of two ways: (1) providing a sling by bringing down two strips of fascia from the rectus sheath and uniting them beneath the terminal urethra (Fig. 4); (2) advancing the urinary meatus to just below the clitoris. The meatus is circumcized leaving a collar one-eighth inch wide. Allis clamps are placed directly beneath the clitoris and laterally at each upper myrtiliform caruncle, forming a triangle to be denuded. A w suture from collar to clitoris raises the meatus, restoring the upward tilt. (Fig. 5.) Similar sutures are placed at both sides and below, closing the denuded area.

The sling operation is technically more difficult. Practically, it is less effective than the advancement operation. Entire repair of the urethrocele from the vaginal approach is the procedure of choice.

Cystocele. (Herniation of the Bladder): The bladder lies behind the pubic bones and in front of the vagina. The base rests against the anterior wall of the vagina and the anterior surface of the cervix to which it is loosely attached by a pair of strong fascial bands, the pubovesical ligaments.

Repair of the cystocele requires: (1) removal of the sac by excision of redundant vaginal mucosa; (2) replacement of the bladder by freeing it from the vagina and

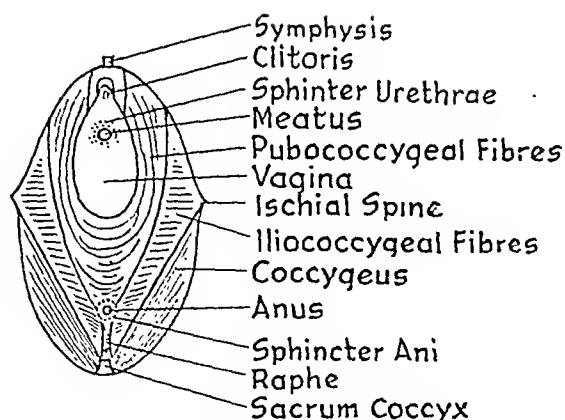


FIG. 1. Schematic pelvic floor.

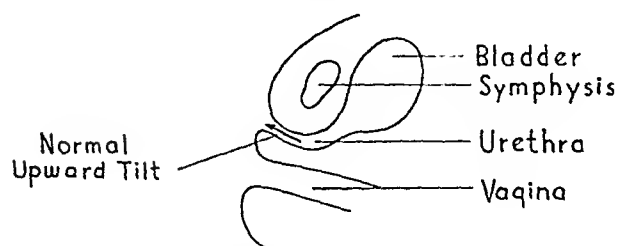


FIG. 2. Normal urethra.

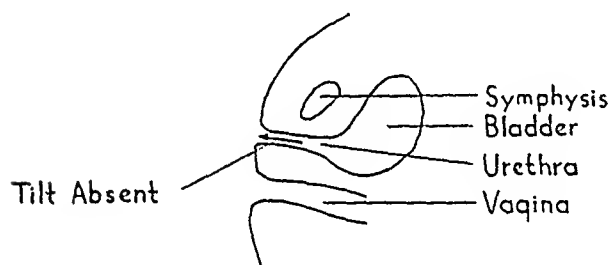


FIG. 3. Damaged urethra.

cervix. The cervical attachment of the bladder must be elevated; (3) repair of the supporting wall by bringing together the pubovesical bands of fascia; then uniting the mucosal edges and suturing those below the bladder to the cervix.

A simple plastic operation on the anterior vaginal wall without elevating the bladder and repairing the supporting floor will almost certainly be followed by recurrence of the cystocele.

Rectocele. (Herniation of the Rectum): The lower third of the rectum is enveloped by loose connective tissue which separates it from the vagina in front. Beyond the coccyx the rectum is supported by the pelvic floor which it pierces to become the anus.

The posterior vaginal wall can be pulled fairly taut but this does not permanently overcome a rectocele. To accomplish this

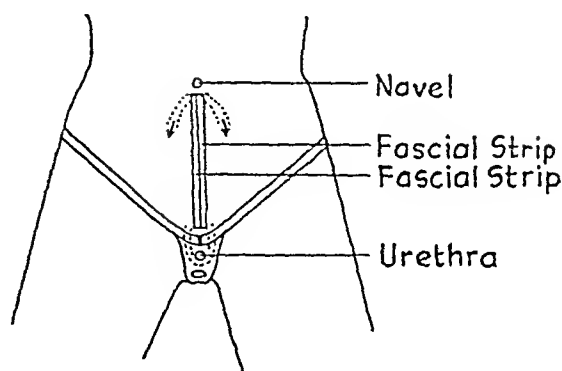


FIG. 4. Sling operation.

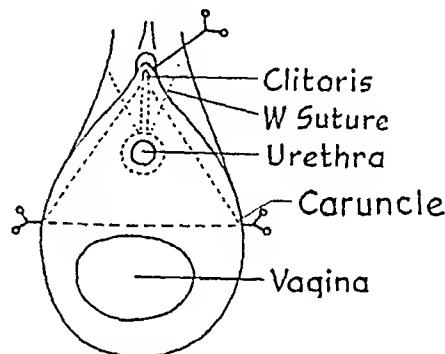


FIG. 5. Advancement operation.

it is essential to: (1) free, replace and retain the entire rectocele; (2) bring together the fascial layers and the levator ani muscles from both sides of the rectum. If the first step is not completely carried out, the upper portion of the rectocele will remain and any strain will balloon it out.

In old women the pelvic floor is apt to consist of weak fascia and scant muscle. In these patients it becomes necessary to improvise to bring relief. The interposition and Lefort operations provide practical solutions in selected cases.

These herniations may occur singly but are usually found in combination. Each must be effectively repaired. Art and imagination will direct the performing hand. Duration of repair will be in direct ratio to restoration of basic structure.

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INTRADERMAL SENSITIVITY TEST FOR AMINO ACIDS

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IN the preoperative preparation of surgical patients as well as in the post-operative management of these individuals, protein replacement therapy is a common procedure. One of the most satisfactory methods of re-establishing a positive nitrogen balance, thus restoring protein to a normal level, is to employ amino acids.

The voluminous use of amino acids has demonstrated that many reactions may be associated with its administration. The reactions may be mild, moderate or severe. In our experience we have witnessed one death. Reactions such as nausea and vomiting do occur and are most distressing to patients following gastrointestinal surgery. Flushing, a sensation of warmth and vasodilatation are occasionally observed. Marked vasodilatation has been known to produce a clinical picture simulating anaphylactic shock. Abdominal cramps and pain with or without associated fever is not an uncommon sequel to amino acid injections.

These reactions have been attributed to pyrogens, rapid rate of administration, the glucose solution and the associated administration of sulfa compounds. When all these factors have been eliminated, reactions still occur. Observation has led us to believe that foreign protein sensitivity is the underlying cause. With this belief as a background, we have employed the routine procedure of intradermal sensitivity test for amino acids.

This intracutaneous test is performed by injecting a small amount of the amino acid solution between the layers of the skin. The test is usually made on the flexor surface of the forearm or the outer aspect of the thigh. In making the test it is most convenient to use a tuberculin type syringe. The needle should be the intradermal size, No. 27 gauge, short bevel. The total amount of solution injected is 0.01 cc. A positive reaction is revealed by redness, heat, swelling and urticarial wheals at the site of injection. Findings such as these preclude the administration of amino acids. The presence of one of these reactions as elicited by the intradermal test warns against the use of the amino acid solution employed in the test. It is interesting to note that a patient may be sensitive to the amino acids manufactured by one company and not to the amino acids from another pharmaceutical house.

Skin tests have been performed after reactions have occurred. Tests of this type have demonstrated that the intradermal test is not only qualitative but also quantitative in that unfavorable systemic reactions were directly proportional to the skin reactions. This procedure has been very simple to follow. On the occasions when a skin test has been employed prior to the parenteral administration of amino acids, it is believed that severe reactions to amino acid intravenous therapy have been avoided.



Case Reports

SURGICAL REMOVAL OF LEIOMYOMAS OF THE ESOPHAGUS

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BENIGN tumors of the esophagus are of considerable interest because of their comparative rarity and because they lend themselves to surgical removal. These characteristics are in contradistinction to those of malignant tumors of this region which are relatively common but are much less amenable to treatment.

A wide variety of benign neoplasms may arise from the esophagus² including adenoma, fibroma, hemangioma, leiomyoma, lipoma, lipomyoma, mucocele, myoma, myxofibroma, neurofibroma, papilloma and polyp. In a series of 7,459 postmortem examinations performed at the Mayo Clinic, thirty-two of forty-four benign tumors found in the esophagus were leiomyomas.³

In a review of the literature from 1717 to 1932, Patterson⁴ found only sixty-two cases of benign tumor of the esophagus. Harrington and Moersch¹ reported a total of fifteen cases of benign tumors of the esophagus from a review of 11,000 cases encountered at the Mayo Clinic in which dysphagia was present.

Benign tumor of the esophagus may occur at any age but is more frequent in the later decades. It is more common among men. The lesions which may be single or multiple, vary greatly in size and may arise at any point in the esophagus.

Benign tumors of the esophagus may be divided into two groups on the basis of their site of origin. The first group is comprised of those tumors arising from the mucosa or submucosa and are com-

monly known as mucosal tumors. They are covered by normal epithelium and are often pedunculated. When they are pedunculated, the tumor may be regurgitated by the patient. The second group of tumors arise from the outer coats of the esophagus and are described as intramural or extra-mucosal growths.

The production of symptoms from these tumors depends on the site of origin, location, size and rate of growth. Most of the tumors grow slowly and many never produce symptoms. The most frequently noted symptoms associated with benign tumors of the esophagus are dysphagia, substernal pain, regurgitation of food, cough and dyspnea.

Diagnosis of benign tumor of the esophagus may be relatively easy when a patient gives a history of regurgitation of a mass into the mouth. Under other conditions, however, diagnosis may be difficult even when the most useful adjuncts of roentgenography and esophagoscopy are employed.

Because of the potential danger of malignant change in these tumors, surgical removal should be considered in all cases.

CASE REPORT

The patient, a man, aged fifty-two years, came to the Mayo Clinic September 10, 1945, complaining of substernal distress of ten years' duration. He had experienced only one or two mild attacks a year and had noticed slight difficulty in swallowing associated with them. He had not regurgitated food, nor were his symptoms related to the type of food eaten.



FIG. 1. Intramural tumor in the middle third of the esophagus and a small tumor above this.

Five years before entry to the clinic he complained of occasional attacks of epigastric pain that were not related to his substernal distress. One year later he had been treated for peptic ulcer without benefit. In April, 1945, he consulted his physician in his home locality who reported, later when he referred the patient to the clinic, that some of the symptoms had been suggestive of a duodenal ulcer, but that the patient had had no pain at night and had experienced incomplete relief from pain after eating. The results of physical examination which included an electrocardiogram at that time were essentially negative. The physician advised the patient to return if his distress recurred. In July, 1945, he had another attack and again consulted his physician. Roentgenologic examinations of the gallbladder, stomach, duodenum and colon gave normal results. Roentgenologic examination of the esophagus revealed a compression and deviation of the middle third of its wall by a lobular mass approximately 7 cm. in diameter. The patient was referred to the clinic for further diagnostic studies and advice on treatment.

When the patient was examined at the clinic, his general condition was good. The systolic blood pressure was 110 mm. of mercury and the diastolic pressure was 74 mm. The value for the hemoglobin was 14.4 Gm. per 100 cc. of blood. The leukocyte count was 9,600 per



FIG. 2. Intramural leiomyomas of the esophagus.

c.mm. of blood. The cause of his father's death at the age of sixty years was a probable carcinoma of the stomach. A sister had died as the result of carcinoma of the breast.

A roentgenogram showed a large, intramural tumor in the middle third of the esophagus. Just above this was a smaller but similar defect. (Fig. 1.) A tentative probable diagnosis of leiomyomas of the esophagus was made. Examination of the stomach did not disclose any abnormality.

Esophagoscopic examination revealed two tumors in the esophagus. The upper one was located at the junction of the upper and middle thirds of the esophagus and arose from the left lateral wall; it measured about 2 cm. in diameter. The lower, larger tumor arose from the anterior and left lateral wall of the middle third of the esophagus and projected into the lumen; it measured approximately 6 cm. in diameter. Both tumors were covered by normal and intact mucous membrane. The appearance was suggestive of fibrolipomas, but the location was more characteristic of that of leiomyomas. Biopsy was not performed because operation was contemplated and it was considered inadvisable to enter the esophageal mucosa.

Penicillin was given for forty-eight hours before operation as prophylaxis against infection. On September 17, 1945, left thoracotomy was performed utilizing a posterolateral incision around the angle of the scapula. A long segment of the fifth rib was resected and the pleura was opened. The larger esophageal tumor was immediately beneath and adjacent

to the arch of the aorta. It was broader than it was long, measuring about 7 by 3 cm., and projected into the right pleural space. The smaller tumor, measuring about 2 cm. in diameter, was higher in the esophageal wall beneath the arch of the aorta. Both tumors were hard and cartilaginous and were located within the muscular wall of the esophagus. A good line of cleavage was found and the tumors were dissected out of the muscular wall without entering the mucosa. The defect in the muscularis was closed with catgut. The operative site was irrigated with solutions of sodium chloride and zephiran chloride. Five Gm. of sulfanilamide was placed in the pleural cavity. The lung was inflated by means of positive pressure and the wall of the thorax was closed in layers without drainage. During the operation, a transfusion of 500 cc. of citrated blood was given.

Pathologic examination disclosed that the tumors were leiomyomas. The larger tumor was

lobulated and measured 8 by 3 by 3 cm.; the smaller tumor measured 2 by 1 by 0.5 cm. (Fig. 2.)

Convalescence was entirely uneventful. Feedings were given through a Levine tube for forty-eight hours postoperatively and then the patient was given food by mouth. He was out of bed on the fourth postoperative day and was dismissed from the hospital on the twelfth postoperative day.

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PNEUMOCOCCAL ARTHRITIS

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PNEUMOCOCCAL arthritis is a rare type of articular inflammation appearing usually as a complication of lobar pneumonia and seen most frequently in adults. It is possible for the primary focus to be obscured by the severity of the local and constitutional reaction of the arthritis itself to the extent that the involved joint appears as a primary process.

Boger in a comprehensive review of the literature cites a total of 227 cases beginning with the first reported case in 1888 by Weichselbaum.

In quoting Herrick's data, there were ninety-seven cases of pneumococcal arthritis occurring in a series of 31,757 cases of pneumonia, an incidence of 0.3 per cent.

In young children the arthritis may be the manifestation of a general pneumococcal septicemia or the general signs of infection may be absent, the bacteria being carried to the affected joint from some focus such as the tonsil. As a rule only one joint is involved, the knee being the most common site. The inflammation may advance to any stage, the joint being distended with greenish, odorless pus containing large numbers of pneumococci.

CASE REPORT

F. W., an obese colored female, age sixty-nine years, was referred to the Passavant Hospital November 8, 1944, suffering from a swollen painful left knee with contiguous swelling of the adjacent soft parts, symptoms of a severe septicemia and a large decubitus ulcer. She had been ill at home for four weeks having suffered a sudden onset of generalized joint pains involving the fingers and elbows of both upper extremities, pain in her lower back, both hips and knees, with the maximum swelling and discomfort settling in her left knee.

Her past medical history was negative in regards to pneumonia or rheumatic fever. There was no previous history or association with the

present illness of cough, pain in the chest or hemoptysis. She was transferred to Surgery on November 15, 1944, at which time she had a tense, markedly swollen left knee joint, sensitive to touch, and she was unable to carry out either active or passive motion. A blood culture taken November 10, 1944, was positive for pneumococci type iii. Her temperature was 102°F., pulse 134 and respirations 36. Sulfadiazine gr. 15 every four hours had been started November 13, 1944.

On November 16th, under gas oxygen anesthesia the joint was aspirated and green odorless pus under great tension obtained. Following culture of the pus the joint was opened by lateral incisions, the pus evacuated and Dakin tubes placed down to but not within the joint. Iodoform gauze packing was used to control marked oozing. The patient's temperature returned to normal following incision and drainage and Dakin's solution were used for irrigation until November 19th when the tubes and packing were removed and daily passive motion begun. The sulfadiazine was discontinued November 29th. a blood culture taken November 22nd showed no growth after seven days. The culture from the aspirated pus contained pneumococci type iii.

The decubitus ulcer was healing under local treatment and a routine culture on January 4, 1945, yielded *Streptococcus non-hemolyticus* and *Staphylococcus aureus*. A walking cast was applied January 13, 1945, to prevent any posterior contracture of the knee and aid the patient in getting about. A carious tooth and several root remnants were removed February 7, 1945, and cultured; the swabs yielded *Staphylococcus aureus*.

An x-ray examination before incision and drainage November 11, 1944, revealed a very extensive arthritis of the left knee joint. A re-examination on December 29, 1944, revealed practically complete destruction of the semilunar cartilages. There was new bone production present about the lower end of the femur and the upper end of the tibia.

The patient was discharged February 14, 1945, with slight limitation of motion in her left knee joint.

COMMENT

A case of primary pneumococcal arthritis, Type III, was observed and no evidence found of a prëexisting pneumonia. Existing dental infection and a decubitus ulcer were both studied bacteriologically and ruled out as possible sources of primary foci. The infection was sudden in onset with generalized joint pains, prostration, a pneumococcal bacteremia and suppuration of the left knee joint. Chemotherapy in the form of sulfadiazine started three days prior to incision and drainage lacked the dramatic

effect of the operative procedure but undoubtedly was the specific factor in recovery.

The x-ray studies revealed joint destruction especially of the cartilages, a condition common to pyoarthritis in general in which cartilage is rapidly destroyed when incubated with pus. Incision and drainage is especially indicated in fulminating cases; however, the availability of penicillin may make this unnecessary as repeated aspiration of pus and the instillation of penicillin directly into the joint may be the only treatment necessary.



With the exception of the streptococcal case, established infection of the hand and fingers should receive energetic surgical treatment at as early a stage as possible. Damage may be done, both by delay and by too vigorous and extensive initial treatment, but there can be no doubt that the commoner errors are those of delay and timid surgery.

From "Minor Surgery" edited by Humphry Rolleston and Alan Moncrieff (Philosophical Library).

ABDOMINAL SKELETINIZED FETUS

WITH UTEROPERITONEAL FISTULA SECONDARY TO CRIMINAL ABORTION

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TWO possibilities present themselves as possible explanations for the development of the condition found in this case. The first, and apparently the more satisfactory explanation, is that the pregnancy was originally intra-uterine. When the instrumentation of the uterus was performed, the uterus was ruptured. The fetus was then extruded into the abdominal cavity as a result of uterine contractions, leaving a uteroperitoneal fistula and explaining the patient's abdominal pain. The fetus then became skeletinized, and fetal bones were passed from time to time through the uteroperitoneal fistula. The only case of this type found in the literature was described by Blakely in 1920.¹ In his case, a self-instrumentation of the uterus was done three months after the patient's last menstrual period. One month later an instrumentation of the uterus was performed under anesthesia and this was followed by severe abdominal pain. A mass became noticeable in the abdomen. The patient was treated conservatively and she recovered. It was then noted that a vaginal fistula in the posterior cul-de-sac had formed with a mass lying behind the uterus. Nine months after onset of pregnancy, a fetal skeleton was removed from the posterior cul-de-sac from below, and it was found lying in a smooth lined cavity which was then thick walled and did not communicate with the peritoneal cavity.

Frommolt, in 1934,² reported a case in which criminal abortion was done, and on removal of the fetus from below, the head was found to be missing. The patient was admitted to a hospital and a laparotomy was done. The uterus was found to be per-

forated, and the fetal head was found lying free in the abdominal cavity.

The second possibility is that the pregnancy was originally abdominal, and, becoming skeletinized, eroded into the uterine canal. A case of this type was reported by Gabrieljantz³ in 1924. This patient a para 1, became pregnant and noted fetal movements at four months. After eight months of pregnancy no further movements were noted, and the patient developed a foul smelling vaginal discharge. She had no bleeding, pain or collapse, though she did pass two small bits of bone which had the appearance of rib. On examination the abdomen was found to be tense, with a mass occupying the entire lower abdomen. Roentgenographic examination revealed a calcified extra-uterine fetus, and a diagnosis of lithopedian was made. Operation was performed, and a large encapsulated cavity was encountered containing the decomposing products of an eight months' gestation. The cavity communicated with the uterine canal, and examination of the fetus revealed that three ribs and the small bones of one hand were missing.

Skeletinized abdominal fetuses have eroded into the rectum, as reported by Gustafson⁴ in 1932, into the bladder and cecum, as reported by Cullen⁵ in 1915 and through the abdominal wall, as reported by Schewket⁶ in 1930. Gould and Pyle⁷ reported that fetal bones have eroded into the intestinal tract and have even been vomited.

CASE REPORT

This thirty-year old mother of four children was admitted to the hospital on July 27, 1945, complaining of foul smelling vaginal bleeding



FIG. 1. Schematic drawing illustrating abdominal skeletized fetus with uteroperitoneal fistula as observed at operation.

and passage of small pieces of bone of one month's duration. Her menstrual periods had been regular and normal until five months previously. She then missed two menstrual periods. Two months before admission the patient had been told that she was pregnant and an attempt at instrumental criminal abortion was made. Thereafter, the patient became very ill, passing considerable amounts of blood and complaining of severe abdominal pain and vomiting. She was confined to bed at home for about three weeks during which time her complaints subsided. One month before admission she began to pass small pieces of bone and the discharge became foul smelling. A second instrumentation of the uterus was performed in an abortionist's office one month before admission. Thereafter the bloody discharge continued unabated and bits of bone were passed occasionally.

Physical examination on admission revealed a somewhat obese woman whose abdomen was soft and relaxed. Her heart and lungs were normal. The cervix was small, smooth, and firm with foul, reddish, purulent material emerging from the os. The uterus was enlarged to about twice normal size and was in second degree retrocession. Anterior and to the left of the

body of the uterus and attached to it there was a soft, tender, nodular area measuring about 4 cm. in diameter. The adnexal regions were somewhat thickened and tender. The ovaries were not palpated. The examination was otherwise essentially negative.

A Friedman test was reported as negative, and a roentgenogram of the pelvis revealed "several densities in the left side of the pelvis having the appearance of fetal bones." Other laboratory studies were within normal limits.

Under the impression that the patient had a missed abortion and uterine leiomyomas, operation was performed on August 3, 1945. After routine preparation and draping the uterine sound was passed and a grating sensation was noted. Without resistance the sound was passed to its full length. Because of the presence of evidence of endometritis and rupture of the uterus, laparotomy was decided upon.

The patient was placed in the supine position and after routine preparation and draping of the abdomen, a low mid line incision was made and the abdomen opened. There was a slight amount of free blood in the peritoneal cavity. The uterus was enlarged, boggy and in retrocession. Anterior to the uterus and to the left

of the body just above the reflection of peritoneum over the bladder, a cavity measuring about 4 cm. in diameter was noted. Lying free in the cavity there were about ten small fetal bones. These were removed. A sound was passed into the base of the cavity and a tract was demonstrated which passed into the cervical canal. The findings are illustrated in Figure 1. Since the opening into the cervical canal was fairly large and the anterior wall of the uterus thin and eroded, it was considered inadvisable to attempt closure of the area. Therefore, a supravaginal hysterectomy was done. Pathological examination revealed moderate chronic endometritis with no decidual or placental tissue in the endometrium.

Postoperatively the patient developed a pelvic abscess which was drained through the cervical stump. A wound infection also developed and drainage was required. The patient then recovered uneventfully and she was discharged from the hospital with no complaints on September 7, 1945.

SUMMARY

A case is reported in which, following a criminal abortion, the patient developed severe abdominal pain and vomiting which

gradually subsided. She then developed a foul smelling vaginal discharge and passed fragments of fetal bone. At operation an abdominal skeletinized fetus with a utero-peritoneal fistula was discovered. Two possible explanations for the development of the condition are presented.

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SKELETAL TRACTION IN THE TREATMENT OF MULTIPLE FRACTURES OF THE THORACIC CAGE*

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THE increase in automobile accidents recently makes the author believe that this is a timely report of a rather simple procedure which can be a life-saving measure for the patient with multiple fractures of the sternum and/or ribs. The physiology associated with the "stove in chest" has recently been discussed¹ so there is no need to dwell on this. However, the treatment reported in the same article involves the use of the Drinker respirator. The Drinker respirator is not always available for the treatment of the patient with the "stove in chest." Other treatments suggested have been open reduction with and without internal fixation, the insertion of tenaculi, and even the passage of a wire beneath the sternum.^{3,4,5} These procedures involve more or less a type of surgery that the patient is in poor condition to undergo. They also involve certain dangers, such as laceration of the internal mammary artery and tear of the pleura. Therefore, a relatively simple procedure is described and a case reported.

TECHNIC

Under novocaine anesthesia a stab incision is made over the sternum in the midline and carried down through the periosteum. Into this incision a small drill point is inserted and a hole drilled into the ventral cortex of the sternum. A medium sized common clothes closet question mark type of coarse threaded hook with tapered point is then inserted in the small drill hole, and with four or five turns it is well fixed in the sternum. In similar fashion a second hook is placed in the other fragment and

traction applied. A double wooden cross-bar is placed between these hooks for external fixation later. The placing of the hooks takes only a matter of a few minutes.

Experiments on cadavers revealed that there was no danger of piercing the posterior cortex with the hook if only five turns were taken. However, care must be taken to avoid drilling through the posterior cortex. To avoid this a drill with an adjustable guard may be used, although one can easily feel the drill pierce the ventral cortex and stop then.

CASE REPORT

A fifty year old white merchant was admitted to the Robert Packer Hospital late on the night of December 11, 1944, after being injured in an automobile accident while he was driving. The essential physical findings included a laceration above the right eye in a somewhat dazed patient. Examination of the chest revealed paradoxical motion of the sternum in that with each inspiration this bone seemed to be drawn into the chest. Palpation revealed a transverse fracture at the junction of the middle and lower thirds. There also appeared to be chondrosternal fractures, third, fourth, fifth, and sixth, on the right and fourth and fifth on the left. With each inspiration the sternum sagged markedly at the fracture site. The blood pressure was 90/60, pulse was 96 per minute, of good quality and regular. Respiratory rate was 32 per minute, temperature 99.2°F. There was no evidence of pneumothorax.

The patient seemed to be in fairly good condition, but by the time the laceration had been sutured respiration became labored and blood pressure had fallen to 60/44(?). Anti-shock therapy was instituted and the patient

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FIG. 1. One hook is shown in place. The lower one attached to the other pulley had just been removed.

responded very well. The patient was placed in an oxygen tent.

The following morning, his temperature was 100.4°F., pulse was 80 per minute, and respiration was 28 per minute. The patient was experiencing considerable pain at the sites of fracture on respiration. All tender points were injected with 1 per cent novocaine with relief of pain on respiration, but the paradoxical motion of the sternum persisted. The lower chest was strapped circumferentially with adhesive but this increased the patient's discomfort and it was immediately removed. Respirations dropped to 18 per minute and the temperature was down to 98.8°F. that evening. The next morning the fracture sites were again injected with 1 per cent novocaine to relieve residual pain. Temperature was 99°F., pulse 20, and respiration 24. The sagging of the sternum persisted. Since it was obvious that vital capacity was cut down considerably, a plan of treatment was worked out to combat respiratory difficulty and/or pneumonia should it develop. This was fortunate since that is exactly what happened suddenly that night. The temperature went from 99°F. to 103.6°F. Pulse was 110 per minute and respirations 50 per minute. There were signs of consolidation in the left lower lobe. Penicillin treatment was instituted.

Under novocaine anesthesia two towel clips were inserted deep in the soft tissues over the sternum and two two-pound weights were used as traction on these. This was an emergency measure and helped the patient considerably. Respirations immediately dropped to 40 per minute after traction was applied. The following morning, it was believed that the skin would not stand up under prolonged traction,

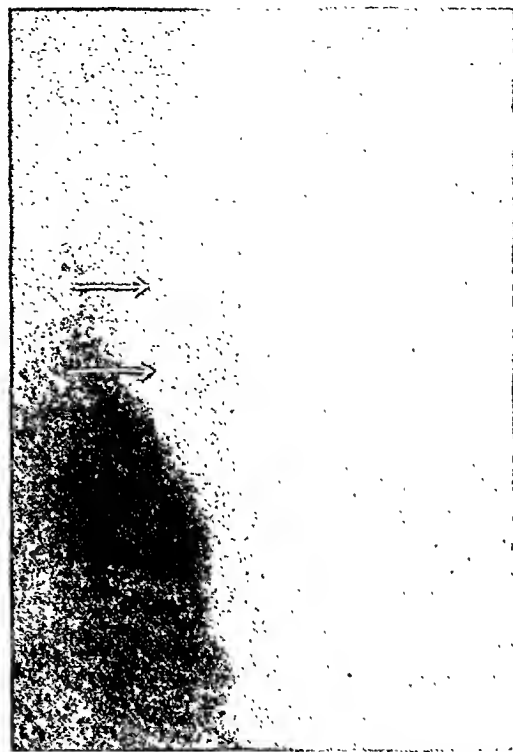


FIG. 2. Lateral view of the sternum showing the fracture at the junction of the middle and lower thirds of the gladiolus.

and the sternum still appeared to sag somewhat on inspiration in spite of the skin traction. Therefore, two hooks were placed in the sternum, one in each fragment as described above under novocaine anesthesia and traction was applied to these. This prevented the sagging of the sternum on inspiration but as a rocking motion was noted, a wooden bracket as a sort of external fixation bar was placed between the two hooks. The patient made a remarkable clinical improvement. Respirations dropped to 24 per minute in the course of the hour. The patient was not put back in the oxygen tent.

In three days temperature, pulse and respiration were normal. Traction was continued for eight days in all, at the end of which time releasing the weights for several hours caused no appreciable change in the patient's condition or the mobility of the sternum. The hooks were then removed without discomfort to the patient, a photograph being taken after one hook had been removed. (Fig. 1.) X-ray taken the following day demonstrated the fracture of the sternum. (Fig. 2.) Three days later the patient was discharged completely asymptomatic.

It would appear that this procedure would be useful in any chest injury with multiple fractures in which a segment of the thoracic cage including the sternum became so mobile that its movement interfered with the maintenance of the normal negative intrapleural pressure. The procedure has been used on a boy, aged nine, with excellent results, as well as the case reported.

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THE commonest cause of delayed union in closed fractures is inadequate splinting. Fractures in certain locations as the neck of the femur and the wrist joint unite more slowly than the average. Most cases respond to further immobilization and frequent application of heat.

From "Fractures and Dislocations for Practitioners" by Edwin O. Geckeler (The Williams & Wilkins Company).

BARIUM AS A FACTOR IN INTESTINAL OBSTRUCTION

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THE surgeon is too frequently asked to see a patient who has developed a complete intestinal obstruction during the course of a roentgenographic examination of the gastrointestinal tract. It has not been an uncommon procedure for many to have a gastrointestinal x-ray series carried out in a patient who presents minimal signs and symptoms of a low intestinal obstruction. The roentgenologist gives the barium by mouth and follows its course throughout the intestinal tract. In some cases the obstruction may be of a sufficient degree that a substance of the density of barium will not pass through and a complete obstruction will be produced. A recent case in which this occurred, and in which the barium in the intestine created the greatest problem, was thought to be of sufficient interest to report.

CASE REPORT

A seventy-one year old female went to her physician because of vague, abdominal, crampy pains which had been present for approximately two weeks. These were associated with an indefinite type of dyspepsia. His examination was essentially negative and the patient was referred for gastrointestinal roentgenographic studies. She was given barium by mouth, and within twelve hours had developed a classical picture of acute large intestinal obstruction. (Fig. 1.) The roentgenograph at this time showed an almost complete intestinal obstruction at the hepatic flexure of the colon. The abdomen was distended with dilated loops of barium-filled small intestine. The patient had acute distress and was vomiting. It was necessary to hospitalize her and to institute continuous intestinal suction, to give intravenous fluids and sedation and to use most of the accepted measures for relief of the obstruction. Approximately one week was required to deflate the intestine and to prepare the bowel

sufficiently so that elective surgery could be contemplated.

At operation, the hepatic flexure of the colon was obstructed by a "napkin ring" type of carcinoma. There was a lumen of approximately 1 cm. at the site of the obstruction. Some barium was still present in the proximal colon and small intestine. A resection of the right colon with a transverse ileocolostomy was performed. The patient made an uneventful convalescence and left the hospital on her eighteenth postoperative day.

COMMENT

It is not unusual, as in this case, for a patient to have a nearly completely obstructed colon and to have relatively few symptoms. This is particularly true when the lesion is located in the right half of the colon because of the soft, semi-fluid state of the bowel matter in this region. When a substance with the consistency of barium is given by mouth to such individuals, it will often precipitate a complete obstruction, as occurred in this case. When this occurs, one has converted an uncomplicated problem into a complicated one, and has inadvertently increased the risk and reduced the patient's chances of recovery. This situation will usually be avoided if a barium enema is given first to all those patients in whom the possibility of a lesion in the lower intestinal tract is considered. When barium is given by this route and an obstruction encountered, the barium, which of course is distal to the obstruction, can readily be removed by an enema.

This approach to the roentgenographic examination of such patients not only has the greatest factor of safety, but is more accurate from a diagnostic standpoint, requires less time and is less expensive. I believe that a gastrointestinal x-ray



FIG. 1. Barium filled intestine with obstruction.

series should rarely be ordered as such, but that one should request examination of the stomach and duodenum, the small intestine or the colon as separate entities depending on the symptoms and findings presented. I am certain that this is generally the commonly employed procedure. However, all too frequently barium is administered by mouth to individuals with signs and symptoms of a low intestinal obstruction, and as a result, the

barium proves to be a factor in precipitating a complete intestinal obstruction when such might have been avoided.

SUMMARY

A case has been reported in which barium administered by mouth during the course of roentgenographic examination of the gastrointestinal tract proved to be a factor in the intestinal obstruction.



New Instruments

METACARPAL FRACTURES

A NEW INSTRUMENT FOR THE MAINTENANCE OF POSITION AFTER REDUCTION

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DEFORMITIES of the hand frequently result from simple metacarpal fractures because of the difficulty of maintaining position after reduction. These fractures are characteristically found in the young or middle aged man, usually the result of a pugilistic encounter, or close hand-to-hand combat with the enemy in time of war. The neck of the metacarpal, being the smallest and weakest portion of the bone, is the most common site of the fracture. The fracture is more frequently transverse in character. The resulting deformity is that of a depression of the head with dorsal angulation of the fragments. The more dorsal the striking force against the head, the greater is the depression of the knuckle. The more direct the force on the head in the longitudinal axis of the metacarpal, the greater the degree of impaction. A tangential force results in depression of the head with impaction and angulation of the fragments.

Ordinarily in this type of fracture, a simple roll of gauze bandage is placed in the palm of the hand. The fist is clenched and immobilized with another gauze bandage. Some recommend bandaging the hand over a tennis ball. More complicated and specialized devices have met with success in the hands of others. Kaplan¹ explains a device for reducing the fracture and holding it in position by the application of an unpadded cast made of two narrow plaster of paris splints. The finger is held in extension and pressure is instituted below the head of the metacarpal and above the angulation while the plaster sets.

Meltzer² employs skeletal wire traction through the proximal phalanx. McNealy and Lichtenstein³ maintain the corrected

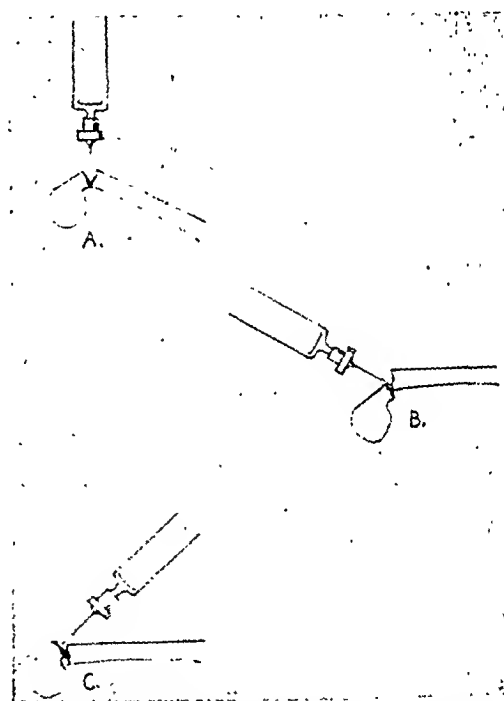


FIG. 1. A schematic drawing demonstrating the various directions of the hypodermic needle to facilitate striking the hematoma at the fracture site. At this point about 5 to 10 cc. of a 1 per cent solution of novocaine is injected in order to produce analgesia.

position with a straight dorsal splint. Wertheim⁴ advocates a kid glove into the finger of which he inserts $\frac{1}{8}$ inch shoe leather to act as a splint. Carr⁵ corrects and maintains the position of the fragments by inserting specially constructed miniature ice tongs into the proximal phalanx.

FIG. 2

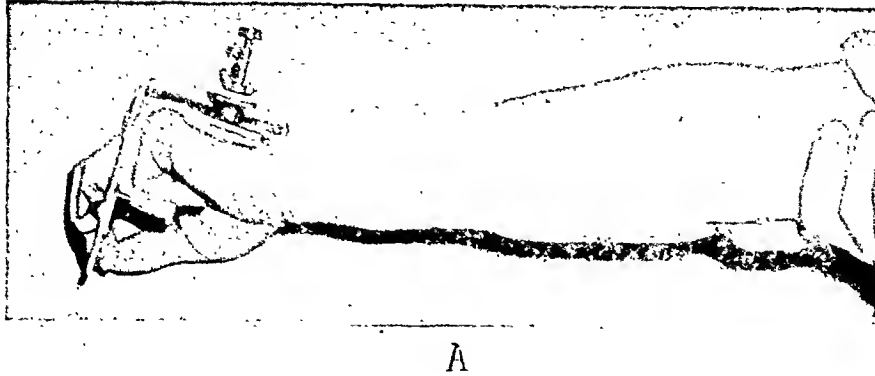


FIG. 3

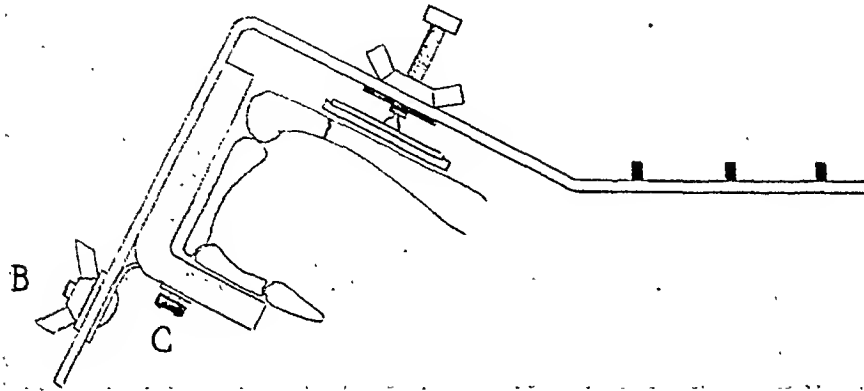


FIG. 2. A photograph of the instrument applied to a fracture through the neck of the fifth metacarpal.

FIG. 3. A schematic drawing of the instrument applied to a fracture through the neck of a metacarpal: A, set screw to adjust upper plate; B, set screw to adjust lower plate; C, set screw to permit rotation of lower plate so as to conform with the deviation of the finger.

Bosworth⁶ first reduces the fragments, then maintains position by fixing them to the adjacent metacarpal with non-flexible heavy wires. Jahss⁷ maintains the position of reduction by employing pressure beneath the head of the flexed proximal phalanx, a procedure similar in certain respects to that recommended in this paper. Davis⁸ maintains position over various sizes of specially constructed wooden balls.

Since this type of fracture is usually first seen by the general practitioner, it is invariably treated by him with one of the many simpler methods available. Unfortunately, in this fracture which is so easily reduced, it is difficult ordinarily to maintain the corrected position. In consequence, many individuals are left with a residual deformity. This deformity in the laborer interferes with his grasp of an implement. The inability to flex the affected finger completely, results in a weakness of the flexion power of the adjacent fingers.

The prominent head of the metacarpal in the palm of the hand causes pain when an object such as a tool is grasped. The professional man, too, finds that this deformity interferes with the full use of both the affected and the adjacent fingers. The depression of the knuckle and the prominence on the dorsum of the hand is cosmetically objectionable to women.

The ball or roll of gauze in the palm of the hand does not counteract but rather emphasizes the angulating pull of the interossei muscles thereby increasing the deformity. Skeletal traction of any form or skeletal fixation introduces the danger of infection and must be considered a specialized procedure. When plaster is used, it is too difficult for the average physician to determine the exact amount of pressure necessary to maintain the position of the fragments. Too much pressure will result in pressure sores during the swelling stage which ensues within a few hours following

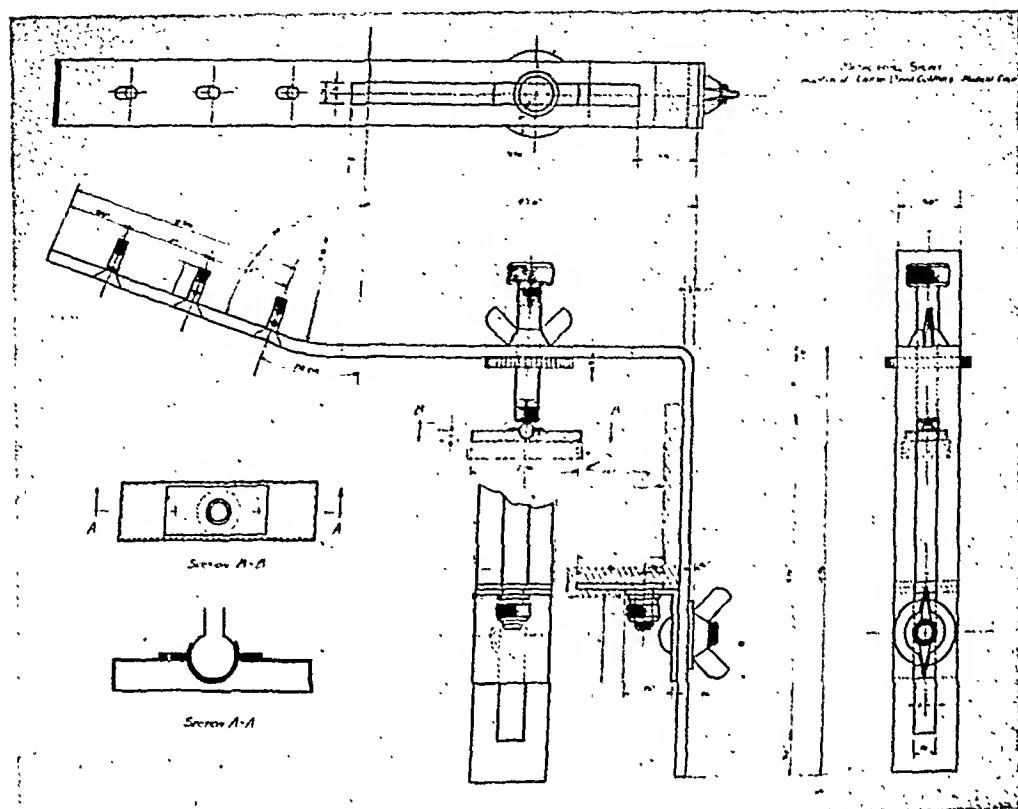


FIG. 4. A mechanical drawing of the instrument.

the reduction. Too little pressure will result in reangulation when the swelling subsides. Constant immobilization of the flexed proximal interphalangeal joint, as advocated by Jahss,⁷ for a period sufficient to see callous on the x-ray film, often results in a flexion deformity.

The instrument to be described is devised primarily for application to the most common type of metacarpal fracture. This, as has been stated, is the simple, transverse, impacted fracture of the shaft. Discussion will be limited to the diagnosis, reduction, immobilization, and after-care of this injury.

Diagnosis. The diagnosis is easily established. There is a history of trauma, swelling, and localized tenderness. Examination shows a depression of the knuckle or head of the metacarpal, protrusion of the metacarpal head into the palm of the hand, and dorsal angulation of the fragments. The latter results in a prominence on the dorsum of the hand. Such findings

warrant x-ray study. The anteroposterior view will best show the site of the fracture, while the lateral view demonstrates the degree of angulation and impaction of the fragments.

Treatment. Analgesia is produced by the injection of 5 to 10 cc. of 1 per cent solution of novocaine into the hematoma at the fracture site. The relationship of the fracture line to the head of the metacarpal, and the angle it assumes with the dorsum of the shaft, are determined by the x-ray film. Because of the dorsal angulation of the fragments, the widest portion of the fracture line is located at the dorsum of the shaft. Since the dorsal aspect of the shaft is rather superficial, it is a simple matter to direct the needle into the fracture line and thus strike the hematoma. The direction of the needle will depend entirely upon the course of the fracture line. (Fig. 1.)

Soft tissue swelling during the period of injection indicates that the solution is being

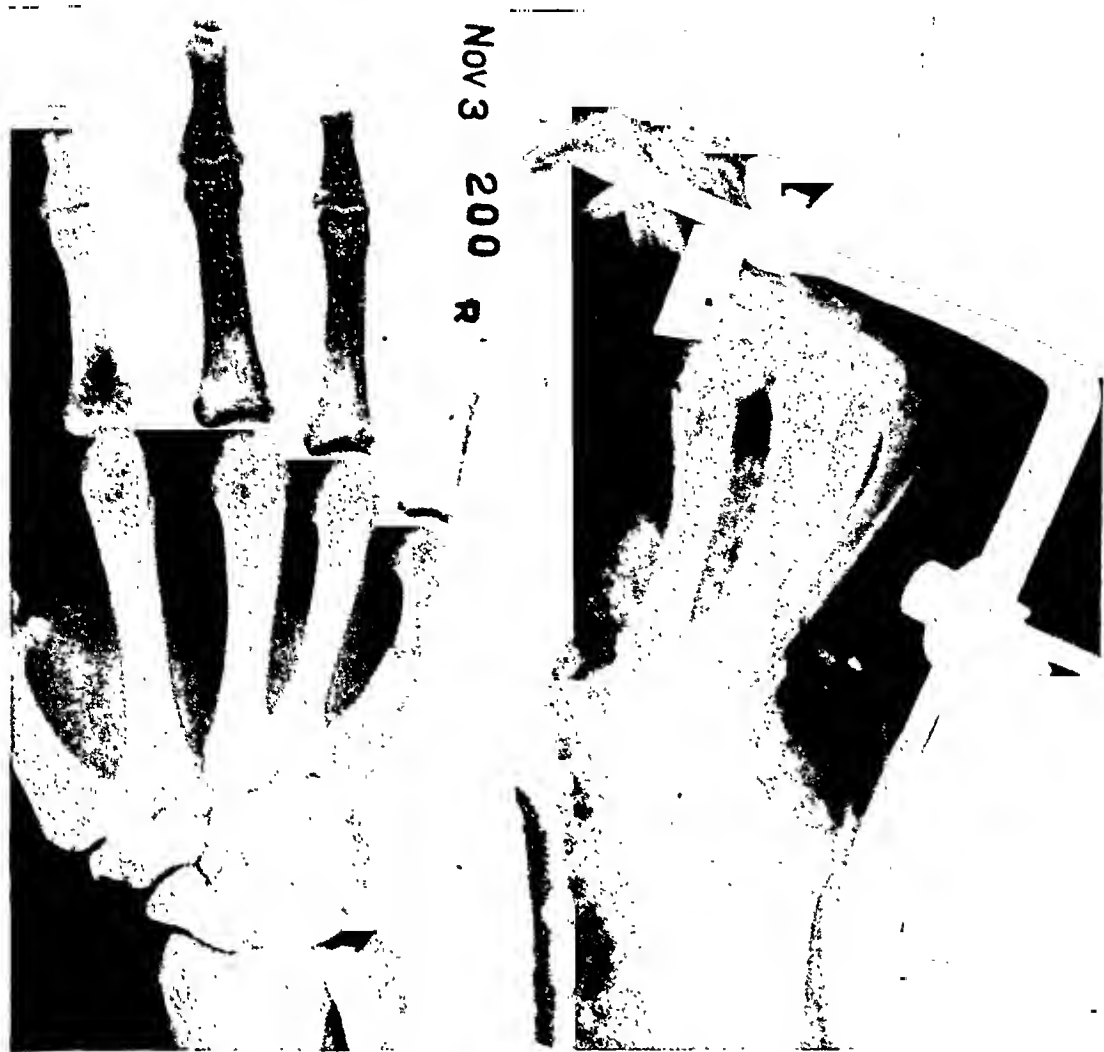


FIG. 5A

FIG. 5B

FIG. 5. A, L. P., twenty-two years of age, fracture of the fifth metacarpal upon admission, November 3, 1942. A lateral view which really demonstrates that the degree of angulation was not available. B, November 9, 1942. Fracture reduced and anatomical restoration of position is maintained by the instrument.

dispersed into the soft parts rather than into the fracture site. Aspiration of bright red blood prior to injection and back pressure into the syringe when the plunger is released during injection may be taken as evidence that the needle is in the hematoma. After 2 or 3 cc. of novocaine solution have been injected the patient may complain of increased pain at the fracture site. This is probably due to the subperiosteal distention. Pain rapidly subsides and analgesia is usually complete in ten to fifteen minutes.

Reduction. The first step is that of breaking up the impaction. This is accomplished by forcefully manipulating the

fragments while strong traction is made upon the finger of the affected metacarpal. After the impaction is relieved, it is then necessary to correct the dorsal angulation and the depression of the metacarpal head. This is accomplished by exerting a downward pressure over the distal end of the proximal fragment and an upward or dorsal force upon the metacarpal head.

With the fracture once reduced, the operator will find that very little upward pressure on the head and downward pressure over the distal end of the proximal fragment is necessary to maintain the corrected position. However, an upward force cannot be made on the plantar

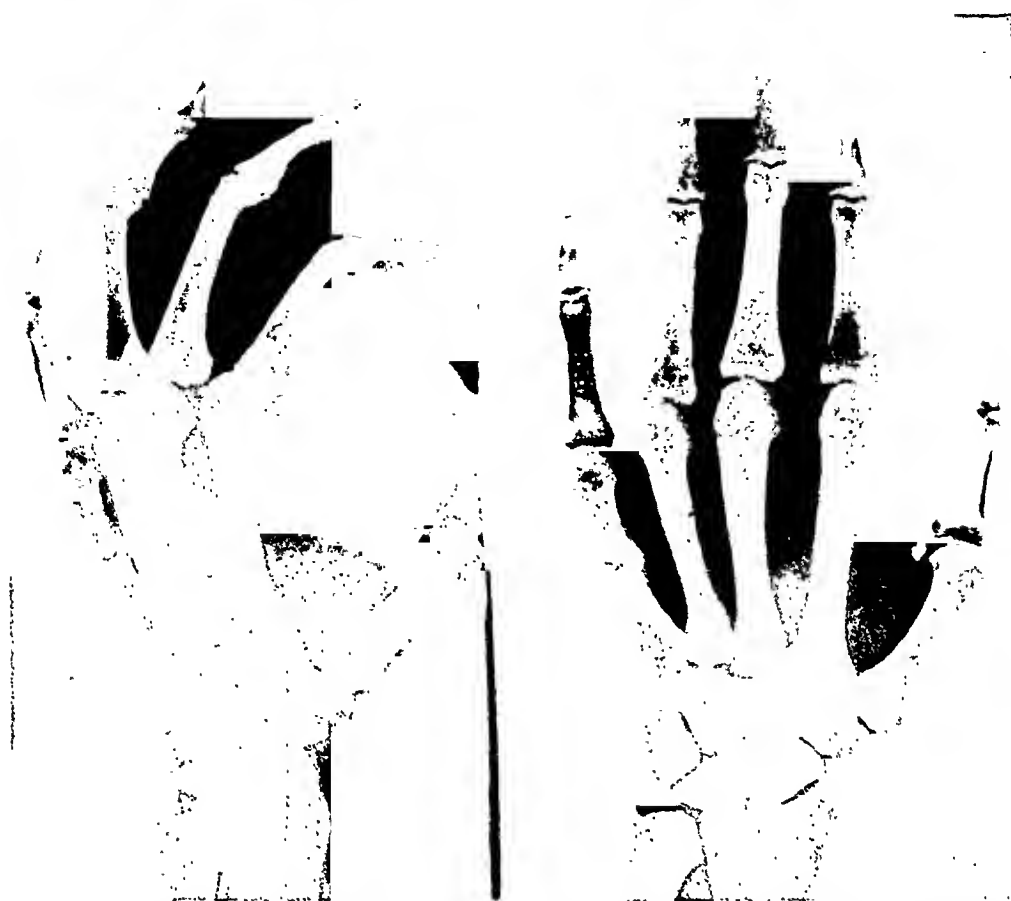


FIG. 5. c, December 15, 1942, six weeks after fracture. Splint has just been removed. Roentgenogram shows the maintenance of anatomical restoration of position. A moderate amount of callous can be seen. Note that the fifth finger can be fully extended. Complete restoration of function was obtained three days later.

surface of the metacarpal head for any great length of time without the expectation of complications. Pressure of any consequence for three to five weeks on the intervening flexor tendon sheath would irritate its membrane and result in thickening and adhesions. In order to eliminate pressure over the flexor tendon sheath, the first phalanx is flexed to a right angle at the metacarpophalangeal joint. This places the base of the proximal phalanx beneath the head of the metacarpal. Pressure upward on the proximal phalanx now forces the metacarpal head upwards. The proximal interphalangeal joint is then flexed to an angle of 90 degrees. Very slight pressure exerted upwards against the head of the proximal phalanx easily maintains elevation of the metacarpal

head and the corrected position of the fragments. The amount of pressure necessary is merely the equivalent of the angulating force caused by the pull of the interosseous muscle.

APPARATUS

The armamentarium necessary to maintain the corrected position of the fractured metacarpal consists of a simple and easily applied apparatus best described in the accompanying photographs and diagrams (Figs. 2, 3, and 4), one four-inch roll of plaster of paris bandage, a small piece of 3" stockinette and any skin adherent. As a finished product and made of aluminum or plastics when priorities permit, the entire apparatus will weigh merely a few ounces.



FIG. 6A



FIG. 6B

FIG. 6. A, E. C., twenty-four years of age, fracture of the fifth metacarpal upon admission, December 7, 1942. B, January 22, 1943, six and one-half weeks after fracture. Excellent alignment of the fragments has been maintained. A moderate amount of callous can be seen. Function was complete a few days after removal of the instrument.



FIG. 7A



FIG. 7B

FIG. 7. A, photograph showing an old healed fracture of the fifth metacarpal treated by splinting over a roll of bandage. Note the dorsal angulation and deformity. The same hand shows a recent fracture of the second metacarpal. B, after closed reduction and application of apparatus.

Application of Instrument. To apply the apparatus the upper and lower screws (Fig. 3A and B) are loosened. The skin adherent is applied about the wrist and distal forearm. This area is covered with 3" stockinette. About five turns of the plaster of paris bandage are taken immediately proximal to the wrist joint over the stockinette. The instrument is then placed over the involved metacarpal and the remainder of the plaster roll is used to secure the instrument to the dorsal aspect of the distal part of the forearm. The plaster sets in a few minutes and the instrument is ready for use. During this procedure the patient maintains the corrected position of the fragments by placing the index finger of the other hand over the fracture site and

his thumb beneath the head of the flexed proximal phalanx, thus making an assistant unnecessary.

The upper set screw is then adjusted so that the pressure plate rests directly over the metacarpal and proximal to the fracture line. The lower support bracket is raised so that it approximates the dorsal surface of the flexed second and third phalanges. The knuckle is thus maintained in its normal prominent position.

If the fifth metacarpal is involved, it will be noticed that the terminal two phalanges will deviate radially. Hence, a third set screw (Fig. 3C) is placed at the lower support in order to adjust it to the proper angle. The lower support is slightly cupped for comfort. The upper plate is supported



FIG. 7. C, twenty-two days after reduction. Compare the anatomical alignment of the second metacarpal treated with the apparatus described and the poor alignment of the fifth metacarpal treated over a roll of gauze bandage.

by a universal joint in order to allow for slight variations in the size and shape of the hand and still maintain an even distribution of force throughout the entire contact surface which is covered with a felt pad.

If swelling is present on the day following application of the device, either one or both of the set screws can easily be adjusted and thus avoid pressure necrosis of the skin. It will nevertheless still be possible to maintain the necessary force to counteract the angulating pull of the interossei.

After a few days all swelling will have subsided. Some fibrous union of the fragments will have taken place. The operator can then hold his finger beneath the metacarpal head, loosen the lower support and carry the flexed proximal interphalangeal joint through a full range of motion. The finger can also be cleaned with alcohol and the skin protected with any oil or cream. This latter procedure should be carried out

three times a week during the entire stage of fixation in order to prevent a flexion deformity at this joint.

The fragments should be supported for about three to five weeks, or until x-ray evidence shows sufficient callous about the fracture site to prevent the pull of the interossei muscles from reangulating the fragments.

When callous appears adequate and the apparatus is finally removed, there is a complete restoration of position without evidence of deformity in any portion of the hand. Two to three days after the removal of the apparatus, patients have been returned to full military duty without any resultant difficulty.

Two instruments may be used side-by-side where more than one metacarpal bone is fractured.

CONCLUSION

A new apparatus has been devised for the treatment of the transverse and im-



FIG. 8A

FIG. 8B

FIG. 8. A, F. G., fracture through the neck of the fifth metacarpal first seen ten days after the injury, April 20, 1944. B, April 28, 1944, excellent alignment. The patient was discharged to full army duty with complete function eighteen days after reduction.

pacted fractures of the last four metacarpal bones. The method of reduction and the use of pressure pads of one form or another have often been used in the past. This instrument, however, can easily be applied and adjusted without fear of pressure sores, infection, loss of position or deformities. It is a simple instrument which anatomically and physiologically answers the purpose of the general practitioner.

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A SIMPLE UTERINE SOUND MARKER

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THE depth of the uterus or length of the cervical canal is frequently measured as part of many diagnostic and operative gynecologic procedures.

cervix and use it as a marker to indicate the depth of the uterus. However, when a bi-valve speculum is used either in the office or the operating room most men rely

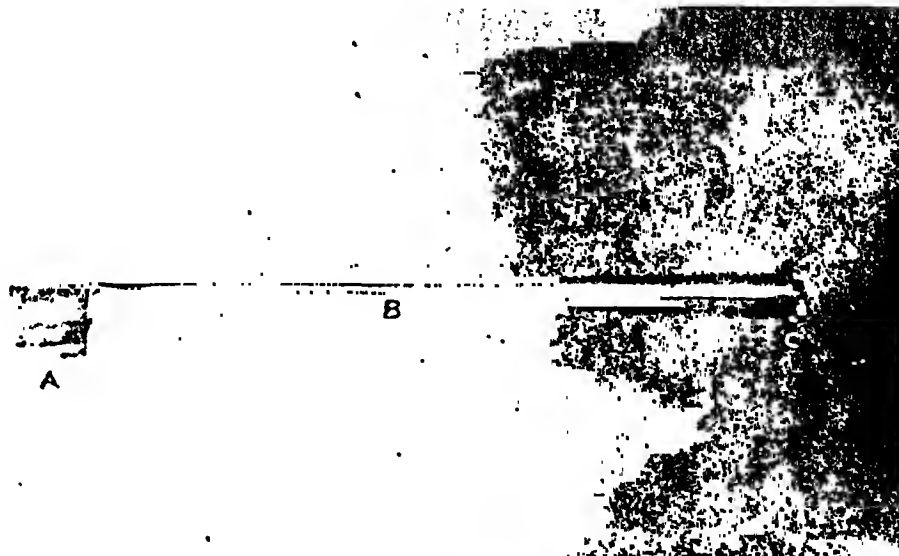


FIG. 1. Uterine sound marker.



FIG. 2. Uterine sound marker attached to graduated sound producing accurate uterine depth gauge.

When the graduated sound is used in the operating room with the cervix pulled down by a tenaculum, it is usually possible to put the finger on the sound against the

on the moisture from mucus or blood on the sound to act as a marker. This usually gives one a rough idea of the length of the uterus. Many times there is insufficient

moisture to act as a mark long enough to observe when the sound is withdrawn. At times if there is bleeding the sound is smeared generally and the estimate of the size of the uterus becomes less accurate.

To overcome the inaccuracy and to insure exact measurements of the cervical canal and the uterine cavity with ease, the marker illustrated was devised. "A" is the spring clip which snaps on and holds rod "B" and indicator "C" on the graduate sound "D." Together the sound and the marker constitute an accurate uterine depth gauge.

In use the instrument is clipped as shown on the sound. It is small enough not to interfere with vision as the sound is inserted in the external os. When the tip of the sound has reached the internal os or the superior wall of the uterine cavity, whichever distance one desires to measure, the marker is pushed forward until the indicator is against the cervix. The sound is then withdrawn and the indicator shows the exact measurement without guesswork. In cases in which an effort is being made to develop an infantile uterus, progress even in fractions of an inch can be ascertained.



RETROFLEXION, simply defined, is a bending backwards of the uterus, i.e., of the body upon the cervix. The latter may still be directed normally downward and backward, but more frequently has tilted downward and forward (erect position of the woman) toward the symphysis as the fundus falls backward.

From "Textbook of Gynecology" by Emil Novak (The Williams & Wilkins Company).

CASSETTE HOLDER FOR THE HAWLEY TABLE*

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IN order to facilitate the taking of anteroposterior x-ray films during the operation of hip nailing, an inexpensive cassette holder has been devised. When ing operation, the technician has merely to raise the drapes from below, remove the exposed cassette, and substitute another for the next exposure.

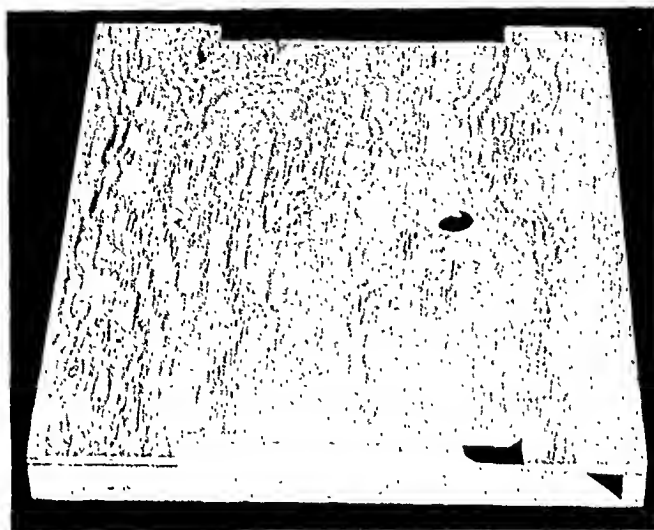


FIG. 1. Tunnel cassette holder, showing 11 inches by 1 inch section removed from each side to facilitate handling of cassettes, and hole for post of table in distal part.

placed under the patient on the Hawley fracture table, repeated films may be obtained without disturbing the position of the patient on the table.

In use, the sacral rest of the Hawley table is removed, following which the cassette holder is placed with its greatest length across the table, and the opening centered over the hole for the center post. The patient is then placed on the tunnel box, the center post inserted through the openings into the post of the table. A 10 by 12 inch cassette is then inserted into the tunnel on the appropriate side, so that the proximal and distal edges are centered for the patient, and the medial border rests against the center cleats. The x-ray is now taken, and when it is developed will include the entire pelvis to the midline. Dur-

The holder consists of a plywood tunnel. (Fig. 1.) Its construction requires two pieces of $\frac{3}{8}$ inch three layer plywood, 20 inches by 24 inches, and a piece of $1\frac{1}{8}$ inch by $\frac{7}{8}$ inch finished stock which is cut into two 24 inch lengths, one $12\frac{1}{2}$ inch length, and one $4\frac{1}{4}$ inch length. Wire brad finishing nails $1\frac{1}{4}$ inches long are also needed.

One of the pieces of plywood is prepared by removing a 1 inch section along each short side commencing 5 inches from one end (which will become the proximal end) and running for 11 inches, so that the uncut remainder is 4 inches. The two pieces now are drilled for the post, using a $1\frac{1}{4}$ inch augur bit, centering the hole 6 inches from the bottom along the center line of the long ends.

*From the Department of Orthopedies and Fractures, Metropolitan Hospital, Dr. Milton J. Wilson, Director.

The cut pieces are now placed above each other and separated by the cleats previously prepared, using the $1\frac{1}{8}$ inch side for separating purposes. The $2\frac{1}{4}$ inch pieces lie along the top and bottom, respectively, and the longer of the short pieces lies along the center line proximal to the opening. The remaining cleat, therefore, lies along the center line from the hole distally. These pieces are then nailed

together using the brads. The entire assembly is shellacked, then varnished, and when dry is ready for use.

CONCLUSION

An inexpensive, simply constructed cassette holder for use with the Hawley fracture table has been described. Its use during the nailing of intracapsular fractures of the neck of the femur is recommended.



PATIENTS with fractures of the lower limb never should be transported until after splinting has been applied. Hospitalization is necessary for the modern treatment of fractures of the leg. Order X-ray examination before deciding upon the method of further treatment.

From "Fractures and Dislocations for Practitioners" by Edwin O. Geckeler (The Williams & Wilkins Company).

The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-fifth Year of Continuous Publication

VOL. LXXII

DECEMBER, 1946

NUMBER SIX

Editorial

ACUTE SURGICAL CONDITIONS OF THE ABDOMEN

THE development of American surgery has been characterized by several great epochs, such as the era up to and including the time of Ephraim McDowell; the Watson, Long and Morton period, in which general anesthesia was introduced; the aseptic age of Lister and Pasteur; the period of the surgical giants, Halstead, Murphy, Senn and Ochsner; the clinic era of the Mayos and Crile; and, finally, the present epoch when improved pre- and postoperative care, chemotherapy, improved methods of anesthesia and early ambulation have proved a most important rôle in surgery.

In no field of surgery have the developments of the present era played a more important rôle than in that of acute abdominal surgery. The tremendous lowering of mortality in acute perforated appendicitis, which in the past thirty years has caused 500,000 deaths, is a triumph of chemotherapy. The sulfonamides and penicillin have largely eliminated the necessity for drainage in these patients and have consequently reduced to a fraction the incidence of complications such as obstruction, abscess formation, wound infection and evisceration. Chemotherapy has also reduced mortality, in acute perforated ulcer and in acute intestinal obstruction necessitating decompression or resection.

By its use better results have been achieved in acute biliary tract surgery.

The introduction of ethylene, cyclopropane, pentothal sodium, curare, and, perhaps most important, improved methods of spinal anesthesia have greatly lessened the problems of the abdominal surgeon. Under spinal anesthesia the abdomen is perfectly relaxed whether one is closing an acute perforated ulcer, exploring the common duct or reducing a strangulated hernia.

Perhaps the most remarkable advancement that has come about in the past five years is early ambulation. It has been difficult to convince surgeons, as well as nurses, long accustomed to keeping their patients in bed for days and even weeks, that getting patients out of bed on the first or second postoperative day results in a far smoother and speedier convalescence. My only regret is that many years ago I did not disregard ideas which were accepted as facts regarding the advantages of prolonged bed rest in abdominal surgery. Early ambulation not only heals the incision speedily by improving the circulation but also reduces the necessity for catheterization and enemas. Normal peristalsis is induced, the patient is able to eat and enjoy food, gas pains are infrequent, duodenal suction and intravenous therapy are

required only in the more critical cases and pulmonary complications seldom occur.

Although great strides have been made in treating acute surgical lesions of the abdomen, the problem of diagnosis often remains a confusing and baffling one that can be solved only by an exploratory operation. For example, I know of no reported instance in which a correct preoperative diagnosis was made in a case of acute torsion of the omentum. Not many years ago I operated upon a boy for acute hemorrhage of a Meckel's diverticulum; this was the first recorded case in which a preoperative diagnosis (established by his family physician) was made of this condition. In 1927, I operated upon a man for acute obstruction and found several feet of thick hose-like jejunum. The diagnosis for this condition was not determined until 1932 when Crohn and his associates at Mount Sinai Hospital established acute regional enteritis as a distinct entity. The roentgenologist has so improved his technic that not infrequently he is able to detect Kantor's string sign in the terminal ileum, as well as other lesions of the small intestine, to aid the surgeon in locating the source of the trouble. Yet occasionally a gallstone may perforate and cause symptoms of acute obstruction far down in the small intestine. Or a young man may be admitted to the hospital in shock after a motorcycle accident; physical examination reveals nothing. Following the administration of blood plasma and further shock therapy he rapidly improves. Ten days later he returns to work, collapses on the third day and is rushed back to the operating room; a laceration of the liver that nature had temporarily walled off is revealed upon abdominal exploration.

The problems of the acute traumatic abdomen in this machine age are such as to bring gray hair to any surgeon, but we have made it a rule at our clinic to operate when in doubt.

Probably the commonest and yet the most confusing diagnostic problem for the thousands of American surgeons remains that of the lowly appendix. The fact that in the past as many as 45,000 cases of perforation have occurred in a single year seems to indicate that a great number of errors occur on the part of someone, the patient, the relatives, the physician or the surgeon. Too many fail to realize that the patient may act and appear well, may have a normal temperature, a normal blood count, but slight rigidity and only moderate tenderness on deep palpation, and yet have a retrocecal gangrenous appendix.

Delay in diagnosis is also largely responsible for the high mortality rate that still persists in acute intestinal obstruction. Earlier surgical intervention in attacking these conditions is imperative if the end results are to be improved.

The art of correct diagnosis has truly been termed the highest achievement of the surgeon. In no other part of the body is his experience and judgment so accurately tested as in the field of acute abdominal surgery. He must not only keep in mind the more important and frequent conditions discussed in this editorial, but must also be prepared to exclude acute lesions of the genitourinary and gynecologic systems. Nor should he forget that coronary disease may occasionally resemble gallstone colic and vice versa and, still more puzzling, that they may both occur in the same individual. He must also remember that pneumonia in children may simulate appendicitis and that enteritis may occur alone or with appendicitis. He should make frequent examinations of the urine to exclude pyelitis if the first specimen is negative.

Surgery in acute conditions of the abdomen is an intriguing and fascinating subject that constantly challenges the skill and ingenuity of the surgeon with its many complex problems.

ARNOLD S. JACKSON M.D.

Original Articles

DIFFERENTIAL DIAGNOSIS IN ACUTE SURGICAL CONDITIONS OF THE ABDOMEN

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PHYSICIANS and surgeons are constantly confronted with the major problem of making a differential diagnosis in a patient suspected of suffering from an acute surgical abdomen. The surgeon is usually called in consultation by the physician who recognizes a surgical emergency. Frequently the decision must be made late at night when the physician sees the patient again or when the patient is admitted to the hospital.

The surgeon should be keen and alert to all possibilities and must make a serious and thorough attempt at diagnosis. There is usually an urgent need for surgical intervention.

A snap diagnosis may be magnificent and may make an impression on some, but it is unsafe and unsound. However, no one can recognize all the possible causes of an acute condition of the abdomen either before operation or before a postmortem examination unless he have the confidence born of youthful inexperience.

Early diagnosis is essential. If a patient has severe abdominal pains lasting longer than six hours and has previously been well, one must suspect a condition of surgical importance.

A history that the patient recently has received a hypodermic of morphine or some other anodyne must immediately make the surgeon suspicious of serious disease.

It is important to keep certain groups of diseases uppermost in one's mind when making a diagnosis, realizing however, that certain rarer conditions might be present.

These groups are: (1) inflammations, (2) perforations, (3) colics, (4) hemorrhages, and (5) obstructions.

The examining surgeon must form the habit of a definite systematic routine examination in every acute abdominal case.

There are certain dicta which are well to keep in mind. Some of them are: (1) It is more important to put the examining finger in the rectum than a clinical thermometer in the mouth. (2) Palpating the pelvic peritoneum is more important than palpating the pulse. (3) Examination of the urine is as important as to inquire about the state of the bowels. (4) Palpation of the abdomen may present muscular rigidity but auscultation of the chest with a stethoscope may show pleurisy or pneumonia.

The knowledge and application of the surgeon's training in anatomy and physiology are of the greatest importance in making a differential diagnosis. He must train himself to think anatomically and physiologically, just as the neurologists and neurosurgeons.

The voluntary muscles and the spinal nerves are the least variable factors in the abdomen.

Early symptoms in all groups may be the same since they all depend on the same cause, such as the shock to the solar plexus, as evidenced clinically by pain, vomiting and shock.

Pain is caused when irritated muscles are moved. Therefore, it is important to include the examination of the state of the

psoas muscle in a suspected case of acute appendicitis.

The anatomical distribution and course of the segmental spinal nerves is an important aid. One remembers that the testicles develop in the same region as the kidney, which explains that patients may have pain in the lumbar region and at the same time also have pain in the testicle. Dorsal distribution of the referred pain is important.

Similarly the diaphragm develops in the region of the cervical segments and later descends, dragging the phrenic nerve with it, which mainly comes from the fourth cervical root. This easily explains why lesions in the lower chest and upper abdomen present pain in the distribution area of the fourth cervical nerve, with referred pain over the shoulder, scapula and sub-clavicular area.

Conversely the pelvic nerves are not represented in the abdominal musculature and therefore patients with a pelvic peritonitis will not necessarily show muscular rigidity.

In the obstruction group of lesions the knowledge of physiology is more important than anatomy. Pain is caused by distention and stretching of the tubes by gas or fluid or by both. Severe colicky pains are caused by an obstruction or reflex spasm of a tube with local distention proximal to it. When strong peristaltic contractions take place, pain is caused. It is then referred to the sympathetic nerve center from which the specific nerve comes. It is also referred to the corresponding segmental spinal cord nerve and its distribution.

Thus colic of the small intestine causes pain in the epigastric and umbilical region. Colic of the large intestine causes pain in the hypogastrium. Biliary colic is felt in the right hypochondrium and the right sub-scapular region. Renal colic is felt in the lumbar region and radiates to the thigh and to the testicle.

Shock is a stage of an abdominal emergency, caused by the sudden stimulation of many nerve centers, as in a perforated ulcer

or the stimulation of a few nerve centers as in biliary colic. Following this initial shock there may be a stage of reaction with a free interval, and this is followed by a stage which is peculiar to each specific lesion.

It is difficult at times to convince a patient and the family of the seriousness of the acute emergency because the first stage of shock may be a transient one. The ensuing free interval is but the calm before the storm, with a renewal of more severe and serious symptoms. Persistence of shock is important, and the pulse pressure may be evidence of the severity of the shock and the impending state of collapse.

METHOD OF MAKING A DIAGNOSIS

Every surgeon develops his own routine in performing an examination of a patient. It may be well to summarize a few points essential to this examination, and then to take up each point separately in greater detail. The essential points are:

1. History of the present illness
 - Age of patient
 - Time and mode of onset of attack
 - Pain and its first situation, shift, radiation, character and pain on micturition
 - Nausea and vomiting, whether before, same time or after onset of attack
 - Movement of bowels
 - Menstrual history
2. Past History
 - Whether patient had a similar previous attack
 - History of indigestion with relation to meals, jaundice, etc.
 - Confinements
3. Physical and clinical examination
 - Pulse, temperature, respiration, tongue and blood pressure
 - General appearance and attitude of patient
 - Abdominal examination
 - Rectal and vaginal examination
 - Chest examination
 - Reflexes—K-J, pupillary
 - Urine examination for albumin, sugar, pus and blood
 - X-ray film of abdomen and lower chest, if available and feasible

AGE

Age may be of help in thinking of possible diagnosis in the various differential diseases.

Disease	Age Factors
Acute intussusception	Usually under two years, may be at any age
Acute appendicitis	Most common in young adolescents, may occur at any age
Acute cholecystitis	Rare in childhood, more common in adult life
Acute pancreatitis	Seldom or never under middle age
Acute regional ileitis	More common in adult life
Perforated gastric or duodenal ulcer	Rare under fifteen years of age
Obstruction of large intestine	Rare before thirty, infrequent before forty, commonest over forty
Obstruction, strangulation of small intestine, especially through hernial apertures	At any time of life
Twisted pedicle of ovarian cyst	Adult life
Derangements of developing ovum and its environment	Child bearing period
Black widow spider bites	At any age, depending on locality of patient

PAIN

The site of onset of the pain, the shifting or the localization of the pain, its character and the radiation are all important factors in the various differential diagnoses.

It is well to remember that the pain is felt at the site of the inflammation if the parietal peritoneum is involved.

The presence or absence of localized pain can be either a good or bad sign. It is a good sign in acute appendicitis if there is localized pain as it means that the parietal peritoneum is involved and adhesions are more

apt to develop. If there is no localized pain it may mean that the appendix is buried in the coils of the intestines, adhesions do not form as readily and spreading peritonitis may ensue. Of course this refers only to the first attack of appendicitis.

Diagnosis	Pain
Acute appendicitis	Arises in epigastrium and shifts to right lower quadrant. May awaken patient out of sleep, is gradual in onset increasing to a maximum, and is aching in character. If accompanied by painful micturition, appendix is likely to be a pelvic one.
Biliary colic	Arises in right hypochondrium. Radiates to the back and to tip of scapula, or to top of right shoulder.
Renal colic	Starts in lumbar region. Radiates to corresponding thigh and testicle. Sharp, constricting and severe in character.
Intestinal colic	Starts in epigastrium. Intermittent, gripping pain. Relieved by pressure of examining hand. Becomes general.
Gastric or duodenal ulcer perforation	Feeling of faintness at onset of pain in upper abdomen. May awaken out of sleep. Is excruciating in character at onset. Pain felt in location where flooding of peritoneal cavity began, then shifts downward as escaping contents pass downward and pain then becomes general.

Diagnosis	Pain	
Acute pancreatitis	Feeling of faintness at onset. Agonizing in character in upper abdomen and then becomes more general.	onset of the attack it is also a serious sign and usually means intestinal obstruction. The relationship of the onset of pain and vomiting is of some diagnostic value.
Abdominal injury with rupture of intestine	Starts in epigastrium and shifts to hypogastrium as leakage descends downward.	Severe pain of biliary or renal colic
Strangulation of intestine	Severe at onset and gradually becomes worse.	Intestinal obstruction
Torsion cyst pedicle		Obstruction upper intestine
Acute mesenteric thrombosis		Obstruction of low intestine
Ruptured ectopic gestation	Feeling of faintness at onset. Pain felt in lower abdomen.	Appendicitis
Obstruction of colon	Pain starts in hypogastrium. Shifts to local site if mesocecum or mesocolon is short. Gradual culminating in crisis.	

It is essential to note the influence of respiration on the pain. If there is pain during micturition, one must consider a pelvic abscess or inflamed appendix but the various kidney lesions such as pyelitis, kidney or ureter stone or acute hydronephrosis or pyonephrosis must be kept in mind. The pain in hydronephrosis or pyonephrosis is much duller in character than in the intraabdominal lesions.

VOMITING

Vomiting, like pain, is a reflex phenomenon. It is, therefore, of questionable value in differential diagnosis. It is caused by irritation of the nerves of the mesentery or of the peritoneum. It may be caused by tension in an involuntary muscle tube. Finally, it is caused by the toxemia of septic peritonitis.

Vomiting usually subsides within twenty-four hours after onset of an acute condition. If it then recurs, it is a serious sign and usually means the beginning of spreading peritonitis. If vomiting persists from the

The frequency of vomiting is of significance. Frequent vomiting in acute appendicitis often means early perforation if it continues early in an attack. If vomiting is frequent later in the attack, it means spreading peritonitis. In the case of a ruptured gestation and in perforated ulcer there may be no vomiting at all.

The character of the vomiting is likewise significant.

Acute gastritis	Stomach contents and little bile
Colics	Usually contains bile
Torsion or stangulation with sympathetic shock	Retching with little vomitus
Intestinal obstruction	Stomach contents, then bile, then greenish-yellow and finally fecal with fecal odor. This always means obstruction, either paralytic or mechanical.

Some patients rarely vomit but may have nausea with loss of appetite. Pain in the abdomen with loss of appetite in a child previously well should always make a sur-

geon very suspicious of acute appendicitis and it must be ruled out.

BOWELS

One cannot put much reliance on constipation or diarrhea. One should always ask the patient when they were conscious of last having passed flatus spontaneously. The question of whether the patient took or was given a cathartic by mouth, or whether an enema was given is of great importance. If there is onset of constipation, pain and flatulence, the patient must be carefully observed. Tenesmus frequently is the symptom of a pelvic acute appendicitis, perhaps with abscess, or of a simple pelvic abscess. Blood and mucus in the stool with pain is suspicious of a possible intussusception.

MENSTRUATION

Always ask a patient the date of onset of the last menstrual period and its character, whether different than usual or whether a change in regularity. If suspicious, ask the time of last intercourse and whether there is a vaginal discharge present. Consider threatened abortion, ectopic gestation if the pain occurred with the period, and especially if this pain is unusual or uncommon for the patient.

PAST HISTORY

Always ask whether the patient has ever had a previous similar attack. Inquire about indigestion and its relation to meals. Question the patient about loss of weight, previous jaundice, blood in the stools or in the urine, or vomiting of blood. Previous illnesses must also be inquired into such as typhoid fever, operations for appendicitis, with or without peritonitis and drainage, pneumonia, etc.

PHYSICAL AND CLINICAL EXAMINATION

Pulse. The pulse may be misleading in the differential diagnosis of an acute surgical condition of the abdomen. After an abdominal injury the pulse should be taken and recorded hourly. It rises rapidly in

hemorrhage. It may be high at the onset after perforation and then go lower, only to rise again when peritonitis sets in. In the early stages of even a severe acute condition the pulse may be normal.

Temperature. This also may be misleading in an acute condition. In inflammations the temperature may not be elevated in the early stages. High temperature with chills and presence of herpes on the lips usually means chest disorders.

Early subnormal temperature	Acute pancreatitis, high later. Aute strangulation, perforated ulcer, hemorrhage.
Early normal temperature then slowly rising to 100°-101° F.	Acute appendicitis
Sudden rise in temperature and drop to normal or subnormal	Perforated appendicitis due to absorption of toxins.
Early temperature 104°-105° F.	Thoracic or kidney disease, rarely in appendicitis.

Respiration. The ratio of the pulse to respiration may be of some value in differential diagnosis. Also whether the rate of respiration is out of all proportion to the abdominal symptoms, and whether the accessory muscles of respiration are active, as the ala nasi. The respirations may be 40 to 50 and the pulse only 100 as in early thoracic lesions.

Intrathoracic lesion	Ratio pulse to respiration less than three to one
Intra-abdominal lesion	Ratio pulse to respiration more than three to one

It may be a fair criterion to say that if the respiration is twice the normal at the onset of the attack, it is probably a thoracic lesion. It is always well to keep in mind that pressure against the diaphragm by an acutely dilated stomach, peritonitis, hemorrhage, or by obstruction with distention, will cause the respiration to be rapid, shallow and labored.

Tongue. It is always a good habit to ask to see the condition of the tongue. It is valuable to note whether it is dry or moist, both at the lateral borders of the tongue and in the center. A dry tongue means dehydration due to loss of fluids, or to sepsis and toxemia.

Acute appendicitis and obstruction	Tongue is coated and there is usually a foul breath
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General Appearance. A great deal can be learned in the differential diagnosis of an acutely ill patient by the facial expression and the position the patient takes in bed when the examining surgeon enters the room.

Perforated ulcer Acute pancreatitis Acute strangulation of intestine Abdominal injury with hemorrhage Ruptured ectopic gestation Severe toxemia of peritonitis	Patient is pale with cold perspiration and lies very quiet Deathly pallor and air hunger with restlessness of patient Sunken cheeks, eyes, and dull gaze. Patient lies immobile, possibly with flexion of knees and thighs.
Colics	Anxious expression, evident extremely severe pain and marked restlessness, usually rolling around in bed.

Examination of the Abdomen. Personally I have always been in the habit of asking the patient to point with one finger to the point of maximum pain. Following this a rapid inspection of the abdomen is done. Look for general or local distention and for evident distended loops or coils of intestines. Also whether there is any evidence of visible peristalsis if distended coils are visible.

Distention of upper abdomen only	Acute dilatation of the stomach
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Distention of the mid-portion of the abdomen with empty lumbar gutters

Distention midabdomen and lumbar gutters

Small intestinal obstruction or paralytic ileus

Large intestinal obstruction or general paralytic ileus

Inspect all the hernial apertures for a swelling and never overlook the femoral ring. Think also of the possibility of internal hernias, or a volvulus, causing the obstruction. Look for evidence of abdominal tumors and swellings.

Limitation of abdominal respiration found in

Acute perforations, biliary colic, pancreatitis and appendicitis.

Palpation of the abdomen must always be most gentle with the warmed hand placed lightly upon the abdomen, using the finger tips gently to elicit evidence of voluntary or involuntary muscle spasm and rigidity. It is well to start the examination at a point distant from the point of maximum pain. Initial examination may be done with the knees extended but if spasm is found it should be repeated with flexion of the knees. Rigidity must be determined to be either voluntary or involuntary, localized or general. Muscular rigidity is a visceromotor reflex. It is due to stimuli received by the spinal cord from a diseased organ. It is nature's effort to protect the underlying diseased organ. It will depend a great deal on the chemical consistency of the fluid which is poured out into the peritoneal cavity.

Gastric contents

Intestinal and bile content

Urine

Blood

Marked rigidity

Moderate rigidity

Less rigidity

No rigidity. Later when blood clots it becomes more irritating.

Differentiation between Voluntary and Involuntary Rigidity. True involuntary rigidity never relaxes however gentle the

examination, however one distracts the patient's attention from the examination, nor is there any relaxation during any part of the respiratory effort. It is an absolute sign of serious trouble, usually with some form of chemical irritation of the peritoneum. It is almost always a strong indication for surgery. Conversely its absence is of no importance as there may be gross hemorrhage within the abdomen without any evidence of abdominal rigidity. The voluntary type of rigidity almost always shows a momentary relaxation of the muscular wall during the respiratory effort. In inflammations the involuntary rigidity becomes more marked as the parietal peritoneum becomes more involved.

Tenderness. Local deep tenderness is always a very valuable sign. It is not always due to pressure directly on the inflamed organ. It is either due to hyperesthesia, which is superficial, and a true viserosensory reflex, or due to irritation of the local peritoneum from stimulation of the subserous nerve plexuses connected with the cerebrospinal system.

Superficial abdominal wall tenderness	More common in respiratory lesions
Local tenderness	Appendicitis Cholecystitis Pancreatitis Salpingitis
General tenderness	Peritonitis

Palpation and bimanual palpation of the lumbar regions detects renal lesions and other swellings. Turning the patient, if possible, to the opposite side and palpating the lumbar regions and along the iliac crest in the iliac flare is of value. At this time one can test for psoas spasm by trying to bring the extended leg backward. If there is tenderness and rigidity in the flank one must consider retrocecal or retrocolic appendix, perinephritic abscess, inflamed kidney, lumbar abscess and hydro or pyonephrosis.

Hyperesthesia. This is a viserosensory reflex. Superficial skin hyperesthesia elic-

ited by either pinching the skin lightly or by a light pin stroke over the skin is not too reliable a test. In certain cases, however, it is difficult to determine the organ at fault and then the test may be of diagnostic value. A clinician may then be enabled to make a keen diagnosis. If positive, it may be of value; if negative, it means nothing. Points of increased skin sensitivity are as follows:

Gall bladder	Mammary line below costal margin
Appendix	Mammary line below level umbilicus
Fallopian tubes	Mammary line above inguinal ligament
Stomach and duodenum	Epigastrium from xiphoid to umbilicus
Small intestine	Below umbilicus
Large intestine	Mid-line suprapubically

Liver Dullness. Examination for presence or absence of liver dullness is of importance. As a positive sign it is important. As a negative sign it is of no significance. If positive, it means a rupture of a hollow viscus. There will be resonance from the fifth rib to the costal margin in the mammary line and from the seventh to the eleventh ribs in the midaxillary line.

Free Fluid. Patients are usually too ill to be examined routinely for free fluid in the abdomen. Shifting dullness may be found in large intraperitoneal hemorrhages as in ruptured ectopic gestation. It may, of course, occur in a rupture of a hollow organ containing much fluid as a full stomach, full bladder or the rupture of a large ovarian or hydatid cyst.

Abdominal or Pelvic Masses and Swellings. These are often noted especially in inflammatory lesions. An appendix mass or gallbladder can sometimes be easily palpated. The danger of the rupture of an appendix abscess by too firm palpation through overlying rigidity must always be avoided. A mass can be felt over an intussusception, malignant growth with obstruction, fecal masses, and rarely over a

large gallstone in the intestines that has ulcerated through the wall of the gall-bladder into the intestine. Omental masses, the policemen of the abdomen, can also be palpated.

Pelvic Examination. The suprapubic region must be palpated and percussed. In the differential diagnosis an overdistended bladder must be kept in mind. If in doubt always pass a catheter. An enlarged uterus also comes into consideration, as well as an ovarian cyst or a pelvic abscess. A bimanual vaginal examination is necessary in every non-virginal female.

Rectal Digital Examination. This should never be forgotten. Pain on pressure with the examining finger tip and pain on movement of the finger tip is important. It must not be pain due to the discomfort of the examination. The examining finger should be introduced under direct vision with good light, slowly, gently and well lubricated. Blood, mucus or pus on the withdrawal of the gloved finger must be noted. If present, suspect intussusception, perforation of a pelvic abscess into the rectum or tumor. Rectal examinations are especially of value in pelvic inflammatory lesions. A mass in the anterior pelvis may be a pelvic abscess, a lateral mass is more apt to be an appendiceal abscess. A high rectal examination may detect a tumor and a stricture.

Auscultation of the Abdomen. This is also of value in the differential diagnosis.

Silent abdomen	Paralysis of the intestines due to ileus or peritonitis
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Gurgling abdomen with pain	Intestinal obstruction
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General Physical and Clinical Pathological Examination.

Chest examination	This is essential in every case and requires careful examinations of lungs heart and pericardium.
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Reflexes	Patella and pupillary
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Urine examination

Blood count

Blood pressure

X-ray Examination. If the patient is in good enough physical condition and x-ray examination is easily available, a film of the abdomen and chest may be of real help in making a differential diagnosis in difficult cases.

Intestinal obstruction

Small intestines

Large intestines

Intussusception

Perforation of hollow organ

reflexes must be tested to rule out tabetic gastric crises. Blood, pus, albumin, sugar and bacteria are important to look for. The patient should be catheterized if necessary before surgical intervention is resorted to.

Always advisable but do not put too much reliance on it. If elevated it helps to confirm the diagnosis. If normal it does not mean anything in the presence of other signs of an acute surgical condition. It should never be taken as a criterion for or against surgical intervention.

The pulse pressure is indicative of the severity of shock and the state of impending collapse.

Distended stepladder coils of small intestine

Distended and collapsed large bowel. It may show the site of obstruction

A barium clysma will confirm the suspected diagnosis

X-ray may show evidence of a pneumoperitoneum

GROUPS OF CASES

Having layed the foundation for the differential diagnosis in an acute surgical condition of the abdomen, it will be wise to say something about the various groups of diseases and to discuss in greater detail the differential diagnosis. More attention will be paid to acute appendicitis and its differential diagnosis as it is by far the most common cause. Abdominal injuries should also be taken up in greater detail.

Inflammations. In this group the onset is not as sudden. The patient usually complains of not having felt as well for a day or

tant signs. The muscular rigidity is of the involuntary type and increases in degree and in extent as the peritoneum becomes more involved. A local swelling may become palpable, such as an inflamed gallbladder, appendix or Fallopian tube, or omentum wrapped around and adherent to one of these inflamed organs.

One of the main and more important differential diagnoses is between acute appendicitis and acute cholecystitis. The question of an empyema of the gallbladder comes into consideration. Some of the more valuable differential points are:

	<u>Acute Appendicitis</u>	<u>Acute Cholecystitis</u>
History	More sudden onset	Gradual onset with history of indigestion
Local rigidity and tenderness	Over McBurney's point. Depends on whether organ is situated low or high	Over hypogastrium right side and below costal margin. Depends whether gallbladder is situated high or low
Cutaneous hyperalgesia	Mammary line just below level of umbilicus	Mammary line just below-costal margin
Respiration	An appendix abscess stays stationary	Gallbladder mass moves downward on respiration
Shape of swelling	Rounded edge above	Rounded edge below
Tympany on percussion	Tympany between appendix swelling and liver	No tympany between gallbladder swelling and liver

so before the onset of the acute symptoms. The pain gradually increases to a maximum over a period of hours. It is not as

In the differential diagnosis between acute appendicitis and acute salpingitis the following points are important:

	<u>Acute Appendicitis</u>	<u>Acute Salpingitis</u>
History	More orderly sequence of events with pain around umbilicus	Less orderly onset with initial pain below level of umbilicus. History of pelvic troubles
Local rigidity and tenderness	Over McBurney's point in an iliac appendix	No rigidity but tenderness on pelvic vaginal examination
Cutaneous hyperalgesia	Mammary line just below level of umbilicus	Mammary line just above inguinal ligament
Abdominal respiration	Some limitation	No limitation
Vaginal examination	No discharge	Usually some vaginal and cervical discharge

severe at the onset as it is in the colics, perforations and some forms of obstruction. The temperature rises slightly and then may go back to normal. One almost always finds local tenderness, be it by abdominal palpation or by vaginal or rectal examination. Tenderness is one of the most impor-

Congenitally the inflamed appendix may be situated in different portions of the abdominal cavity. Much depends on whether complete rotation and normal descent of the cecum has taken place. This fact will also determine whether the appendix lies free in the peritoneal cavity or whether it

is partially or wholly covered by perietal peritoneum and lies completely retroperitoneal. Depending then upon the position of the appendix various pathological conditions have to be considered in the differential diagnosis of acute appendicitis. They are:

Ascending Appendix
Duodenal ulcer
Cholecystitis
Perforated gallbladder

Iliac Appendix
Leaking perforated ulcer
Ileocecal tuberculosis
Cecal carcinoma
Mesenteric lymphadenitis
Psoas abscess
Hip disease

Pelvic Appendix
Meckel's diverticulitis
Diverticulitis with abscess
Perforated typhoid ulcer
Ureter calculus
Intestinal obstruction
Female patients
Ectopic gestation
Salpingitis
Ruptured pyosalpinx
Twisted pedicle of
Hydrosalpinx
Ovarian cyst
Pedunculated fibroid

Intussusception. This usually occurs in young children. It may occur also in adults and then usually is caused by a neoplasm, benign or malignant, within the lumen of the gut. This invaginates itself into the bowel and draws along the intestine in an intussusception. There is quite some pain at the onset, accompanied by initial reflex vomiting and a mass can frequently be felt along the colon at the site of the intussusception. Blood and mucus are present with some pain on bowel movement. It may also be found on the examining finger on rectal examination. A barium clysma, if available and feasible, will verify the diagnosis.

Acute Pancreatitis. This acute surgical emergency is one of the rare ones to keep in mind. Still one must always be cognizant of its possible presence. It is sudden in onset, severe in character, and a true surgical emergency. The pain in the epigastrium is severe and is often mistaken for a perforation. There is early reflex vomiting, shock, subnormal temperature at first followed later by high temperature and a very rapid pulse. Tenderness and local rigidity are confined at first to the epigastrium over the pancreas and later become more general. Abdominal respira-

tion is limited in extent. The blood count is high. The disease accounts for less than 1 per cent of all acute abdominal conditions.

Regional Ileitis. This condition is rarely an acute surgical emergency, although it is possible that a perforation of the ileum without sufficient adhesions could present

the picture of a spreading peritonitis. The condition is present for a longer time and when it becomes acute it resembles acute appendicitis. There is right lower quadrant pain and the patients have fever, vomiting, and sometimes diarrhea and a secondary anemia. Internal perforations occur but adhesions are usually present. Later in the disease external perforations may occur.

Hemorrhages. If the hemorrhage occurs into the lumen of the alimentary canal or into any organ lined by mucous membrane, the blood will appear at one of the orifices. If the bleeding is into the stomach, it will appear at the mouth; if it is from the upper alimentary tract or from the bowels, it will appear at the rectum. Uterine bleeding will appear at the vagina. Hemorrhage into the peritoneal cavity is more serious as it is not irritating to the peritoneum in the early stages. It may, therefore, continue unnoticed. The abdomen is soft and not distended. The patient, however, becomes restless and the pulse rises rapidly. If there has been a sudden onset of these symptoms with pain in the abdomen, think of hemorrhage. The patient becomes increasingly pale. Repeated blood counts, especially the hematocrit deter-

mination, is of real value. It will help to determine the extent, degree and persistence or cessation of the bleeding. Auscultation of the abdomen is of value as it will usually be a silent abdomen. The most common causes are trauma and ruptured ectopic gestation.

The main differential diagnostic points are

Ruptured ectopic gestation	Restless, no abdominal rigidity
Perforated ulcer	Patient lies absolutely still with marked abdominal rigidity

Perforations. The history in the majority of cases will be of value. Indigestion has usually been present although this history may be entirely lacking. The onset is sudden, may occur during sleep and awaken the patient. It may also occur after bodily strain and exertion, or without any warning or predisposing cause. The pain is excruciating and there is initial shock. This shock may soon pass off. Involuntary abdominal muscle rigidity is present over the entire abdomen. The pain at the onset is usually at the site of the organ that perforates, and then becomes general as leakage and descent of the same takes place. Peritonitis sets in. Free gas in the abdominal cavity is frequently present. It can be found while examining for liver dullness by percussion. It may be seen as pneumoperitoneum by x-ray examination. It accumulates usually under one or both leaves of the diaphragm, especially in the erect posture. A fluid level may be present. Limitation of abdominal respiration is marked. Testing for cutaneous hyperalgesia may be of value in a few cases in determining the organ at fault. It may help in difficult diagnostic cases to make a correct preoperative diagnosis. Operation and early operation alone will definitely show the organ at fault. The possibility of perforation in a retroperitoneal portion of one of the hollow organs must be kept in mind. It is important to make the differential diagnosis between perforation of a

gastric and duodenal ulcer, biliary and renal colic and conditions as gastric crisis of tabes dorsalis and thoracic disease as pleuropneumonia. In the former, surgery is indicated, while in the latter (tabes and pneumonia) surgery is distinctly contraindicated.

Colics. These are usually sudden in onset, sudden in cessation and equally sudden in recurrence. Reflex vomiting occurs. The pain is at first felt near the structure at fault. Radiation of the pain is of great diagnostic value.

Biliary colic

Pain referred upward into the back, tip of the scapula, top of the shoulder. There is limitation of abdominal respiration.

Renal colic

The pain in the lumbar region is referred downward to the thigh and testicle of the corresponding side. There is no limitation of abdominal respiration. Frequency of urination occurs and there are red blood corpuscles in the urine.

Intestinal colic

The pain occurs all over the abdomen. Pressure of the examining hand on the abdomen sometimes relieves the pain, which is not the case when peritonitis is present

The hollow tubes composed of smooth muscle fibers which cause these colics if obstructed are: stomach, intestines, cystic, hepatic and common bile duct, ureters, uterus and Fallopian tubes and pancreatic duct.

Obstructions. There are very distinctive signs and symptoms in intestinal obstruction. The diagnosis should be made as early as possible as surgical intervention is usually indicated. The judicious use of the

Miller-Abbott tube is of value in deferring surgical intervention. It deflates the intestine and reduces the toxemia caused by absorption of the poisonous intestinal contents. Operation can be held in abeyance for a while, but if the Miller-Abbott tube does not pass readily its use should not be persisted in. Surgery is indicated.

Persistent vomiting from the onset of an attack with cessation of the passage of flatus and progressive abdominal distention is a signal for intervention, with a diagnosis of obstruction. If flatus does not pass together with dark intestinal content within twenty-four hours in spite of enemas, well given colonic irrigations and the careful use of prostigmin, the diagnosis of obstruction can be made. With the development of distention, individual loops of intestines may become visible if the abdominal wall is not too thick. Painful peristalsis may be seen. Auscultation of the abdomen is of value, as the characteristic gurgling and passage of fluid and gas through large distended coils of intestines may be heard. Fecal vomiting should never be mentioned as a symptom of obstruction. It is a terminal symptom, and the diagnosis should be suspected and should be made before the fecal vomiting sets in. The obstruction should have been relieved beforehand.

If obstruction is suspected in the differential diagnosis, the abdomen should be carefully examined for previous operative scars with possible adhesions and bands. A previous acute appendicitis with or without drainage should arouse suspicion.

Strangulated loops of intestines through the external hernial apertures, inguinal, femoral, umbilical, ventral, must always be looked for. At the same time strangulation due to internal volvulus and internal hernias must be considered.

X-ray examination with a film of the abdomen will show the typical stepladder distended loops of small intestine, and the distended or collapsed large intestine.

Certain conditions closely simulate the primary obstruction of the large bowel and come into consideration in the differential

diagnosis. These are colitis with distention; paralytic ileus of the bowel, reflex ileus; uremia, and reflex paralytic ileus due to peritonitis.

EARLY DIFFERENTIAL DIAGNOSIS IN ABDOMINAL INJURIES

If there is a history of abdominal injury however slight it may have been, a serious intra-abdominal injury must always be considered. The patient should preferably be hospitalized and must be under constant careful observation. An hourly pulse record must be kept. Repeated blood counts and hematocrit determinations must be taken to give a clear picture of what may be occurring within the abdomen. The two common differential conditions are hemorrhage from solid organs and rupture or tears of hollow organs. If either of these conditions occur within the peritoneal cavity or in the retroperitoneal space, they are of equal importance. Injury to the liver, spleen, pancreas or the kidneys cause hemorrhage. If the kidneys are injured, there is also a leakage of urine. Injury to the hollow organs as stomach, intestines, gallbladder, ureters and bladder cause leakage of the contents with shock and peritonitis.

Following injury to the abdominal wall rupture of the intestine is the most common damage. As seen in war surgery, as well as civilian surgery, tears of the intestines may temporarily seal themselves off, while the bowel is reflexly paralyzed. After an interval of time or after taking nourishment peristalsis again sets in. The sealed off tear will begin to leak and peritonitis will follow.

The possibility of retroperitoneal rupture of the duodenum or of the colon with hemorrhage, must be kept in mind. Emphysema and cellulitis must be looked for at the time of operation. If found the condition must be corrected in order to save the patient.

If shock is still present three hours after an abdominal injury, the probability of some serious injury to some organ is likely. There will be pain, vomiting, local

or general rigidity, tenderness, advance in pulse rate, shallow respiration, restlessness if due to severe hemorrhage, obliteration of liver dullness and evidence of free fluid in the abdomen. Increase in temperature will follow.

A very important differential point to ask the patient is whether the injury occurred shortly after eating or whether it occurred before or just after emptying the bladder. A distended stomach or bladder is more apt to rupture than one that is empty.

If an injury to the bladder is suspected, a catheter should be passed. If no urine is obtained, a little saline may be gently injected. If materially less in quantity than what was injected is recovered from the catheter, a rupture of the bladder can be suspected.

In the differential diagnosis after injury the thorax must be carefully examined. Fractured ribs, pneumo or hemothorax, hemo or pneumopericardium must be looked for as these may give evidence of abdominal signs.

MEDICAL CONDITIONS IN THE DIFFERENTIAL DIAGNOSIS

There are finally various pure medical conditions that must be considered. Their presence may cloud the diagnosis. A surgical condition of the abdomen may be suspected when only a medical condition exists. The most common of these are:

Intrathoracic lesions

- Acute basal pneumonia,
- Acute diaphragmatic pleurisy,
- Acute pericarditis,
- Angina pectoris and
- Acute pneumopericardium.

Renal disease

- Uremia. Always remember its possibility.
- Urine must be examined in every case.
- Uremia may simulate large intestinal obstruction.

Spine and spinal cord lesions

- Tabes dorsalis with gastric, intestinal and renal crises. Pupillary and patella reflexes to be examined.

Blood diseases

- Leukemia. Will show enlarged spleen
- Acute infectious mononucleosis

General diseases

- Influenza
- Malaria
- Diabetes, impending coma
- Typhoid fever
- Tuberculous peritonitis
- Gonococcic peritonitis (abdominal puncture may aid in diagnosis)
- Ptomaine poisoning

Retroperitoneal conditions aside from acute pancreatitis

- Dissecting abdominal aneurysm
- Rupture of aneurysm of aorta or other abdominal vessel
- Retroperitoneal bleeding from kidney tumor or retroperitoneal tumor as sarcoma
- Retroperitoneal extravasation of bile or urine
- Pelvic infection which is subperitoneal due to extravasation following traumatic rupture of rectum at time of enema, etc.
- Retroperitoneal hemorrhage from fracture of contingent bones.

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DIFFERENTIAL DIAGNOSIS OF SURGICAL RENAL LESIONS*

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THE differential diagnosis of surgical renal lesions is here considered particularly from the standpoint of the



FIG. 1. Stricture of the right ureter in a three-year old child whose abdominal pains had caused appendectomy to be done for "recurrent appendicitis." All symptoms were subsequently relieved by systoscopic dilatation of the ureter.

general surgeon rather than the urologic specialist. Perforce, the abdominal surgeon too often only encounters the repetitious, vague abdominal pain frequently found on the right side and to which clinical picture the diagnosis of "chronic appendicitis" or "abdominal adhesions" is erroneously given. Yet appendectomy or exploratory laparotomy fails to relieve the existing symptoms and subsequent investigation

commonly discloses unsuspected urologic disease. It is not uncommon to find some variety of ureteral obstruction or a renal lesion. (Fig. 1.)

The diagnostic difficulties are at once apparent when it is recognized that practically every renal surgical disease may present a similar clinical picture although it is often not noted in the usual text book description. Thus chronic renal tuberculosis may simulate non-tuberculous chronic pyelonephritis, with secondary vesical involvement. The resulting urinary frequency causes the diagnosis of chronic cystitis to be made and the renal lesion overlooked. With the passage of clumps of tuberculous debris, the resulting renal colic may simulate ureteral stone; a partially or completely occluded tuberculous kidney with its advanced surrounding fibrolipomatous perinephritis and periodic hematuria, may closely simulate renal tumor.

In all cases, careful urinalysis of a properly collected specimen is of paramount diagnostic importance. When urologic disease and particularly when infection is suspected or must be considered in the differential diagnosis, examination of the casually voided specimen is essentially worthless. In over twenty-five years we have never examined a voided specimen from the female but insist on catheterization in both the newborn and the aged. Only by aseptic catheterization can bacterial and cellular introital contamination be avoided. In the male a satisfactory specimen can be obtained by washing the exposed glans penis and external meatus with an antiseptic solution such as oxycyanide or bichloride of mercury 1:1000, after which the patient passes a few cubic centimeters of urine; into the continuing urinary stream

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FIG. 2. Characteristic roentgenographic findings in perinephric abscess. Noteworthy are the lateral sclerosis away from the side of the lesion and the obliteration of the shadow of the ipsilateral psoas muscle (left).

a sterile receptacle is introduced for specimen collection. This avoids extraneous cellular or bacterial contamination and if the procedure cannot be carried out satisfactorily, catheterize. In the subsequent examination of the urine we are interested primarily in the pus, blood and bacterial content, slightly less in the sugar content, and least of all in the albumin and cast elements. Yet the demonstration of pus casts at once establishes the presence of suppurative pyelonephritis. Cure of urosurgical disease implies a restoration of the urine to normal, and this includes sterilization as attested by at least two negative cultures of properly collected specimens. This dictum holds whether the basic disease is chronic pyelonephritis, infected hydronephrosis, renal tuberculosis, calculus or tumor. In addition to these conditions will be considered acute renal infection and congenital malformation.

SURGICAL NON-TUBERCULOUS RENAL INFECTIONS

As a rule the diagnosis in non-tuberculous renal infection is either acute or chronic "pyelitis." Properly pyelitis denotes inflammation of the kidney pelvis, yet to date such inflammation without involvement of the renal parenchyma has never been demonstrated. In renal infection, the usual lesion is an interstitial suppurative nephritis which may exist alone or as a complication of another condition such as stone or obstruction. In persistent acute renal infection, failure of intensive medical therapy (sulfonamide, penicillin, streptomycin) to bring about striking improvement in three to four days, calls for complete urologic examination by which the probable anatomic diagnosis will be made. This investigation will usually reveal infected hydronephrosis, generally

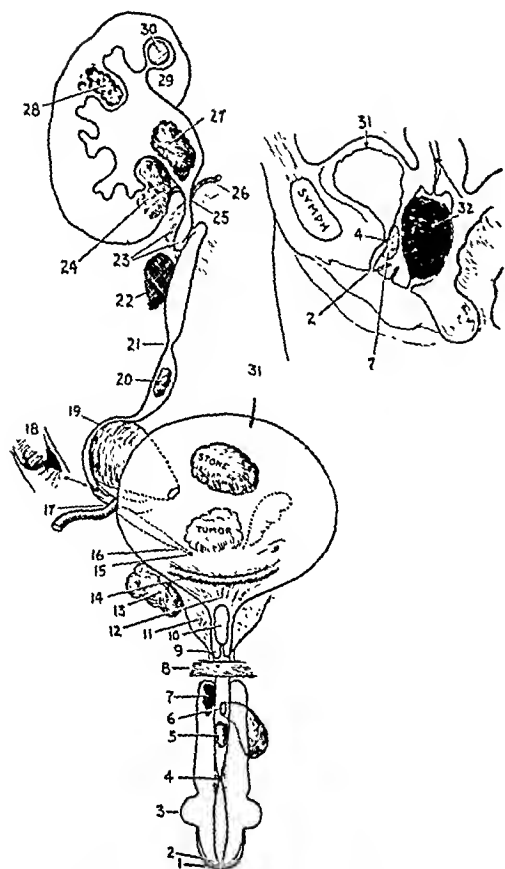


FIG. 3. Causes of urinary obstruction and, by the same token, hydronephrosis. 1, Phimosis; stenosis of prepuce; 2, stenosis of urethral meatus; 3, paraphimosis; 4, urethral stricture; 5, urethral stone; 6, urethral diverticulum; 7, periurethral abscess; 8, external sphincterospasm; 9, congenital valves of posterior urethra; 10, hypertrophy of verumontanum; 11, prostatic ansecess or growths; 12, contracted bladder neck; median bar; 13, periprostatic abscess; 14, mucosal fold at bladder outlet; trigonal curtain; 15, stricture of ureteral meatus; ureterocele; 16, ureterovesical junction stricture; 17, vascular obstruction of lower ureter; 18, congenital ureteral valves; 19, ureteral obstruction by vesical diverticulum compression; 20, ureteral stone; 21, ureteral stricture; 22, peritubercle or tumor; 23, ureteral kink; periureteral fibrous bands; 24, renal tumor; 25, ureteropelvic junction stricture; 26, aberrant vessel obstruction of upper ureter; 27, pelvic stone; 28, renal tuberculosis (secondary obstructive lesions consequent thereto); 29, stricture of calyceal outlet; 30, calyceal stone; 31, neuromuscular vesical disease; 32, urethral compression by hematocyclometra.

consequent to blockage of the pelvic outlet or upper ureter by stone, stricture, malposition, an aberrant vessel, or perirenal

abscess. Also there may be either massive metastatic focal infection (pyemic kidney), or solitary renal abscess (renal carbuncle). Sometimes the obstruction can be relieved and the organ preserved but here the surgeon replaces the kidney with the reservation that prompt secondary nephrectomy may be demanded or late secondary renal sclerosis may be the cause of hypertension in later months. Sometimes surgical exposure discloses massive suppuration and, when unilateral, nephrectomy rather than simple renal drainage is required. Occasionally, drainage of a perirenal abscess or coring out and drainage of a solitary renal abscess (renal carbuncle) is curative.

Any retroperitoneal edema-producing process such as perinephric abscess will roentgenographically obscure the ipsilateral psoas muscle outline. (Fig. 2.) As a rule, in perirenal abscess compensatory muscle spasm of the ipsilateral erector spinae group produces lumbar curvature away from the site of the lesion. When a patient presents (1) the picture of acute intra-abdominal disease but with unilateral renal tenderness and spasm of the overlying loin muscles, and (2) has a history of cutaneous infection (boils, carbuncles, furuncles and paronychia) during the past three months, the roentgenologic demonstration of obliteration of the psoas muscle outline together with spinal curvature toward the opposite side, at once suggests perinephric abscess. (Fig. 2.) Yet retrocecal appendicitis with edema may produce essentially the same roentgenogram and the diagnosis appendicitis rendered more likely by the urographic demonstration of a normal upper urinary tract.

Moreover, the same picture of acute surgical disease is presented by the rare renal thrombosis or infarction, but this occurs more often in the young, notably infants. This condition is generally immediately preceded by acute ileocolitis and the renal onset is acute with abdominal pain, rapid renal enlargement, tenderness, variable shock and prostration. Here the pyelo-



FIG. 4. Hydronephrosis due to ureteral obstruction by carcinoma of the broad ligament. Here the parenchyma has been reduced to a thin shell. Longitudinal ureteral dilation has resulted in several secondary kinks in the upper end of the duct. The clinical manifestations were pain and mass in the side with scatter leucocytes in the urine.

graphic outline may be obliterated by the intense massive parenchymal swelling and at operation (when the precise diagnosis will most often be made) the kidney is found converted into a large blood clot-like mass. Nephrectomy is the treatment and to be life-saving must be immediate. I have successfully performed nephrectomy for renal thrombosis in two boys twelve and thirty-three days of age.

In short, when hyperacute renal infection persists, and especially unilaterally, prompt urologic examination is indicated

and the resulting demonstration of infection, pyelographic distortion or obliteration will suggest the probably surgical diagnosis, but this will sometimes be modified or changed upon exposure of the kidney which is the immediate indication.

In chronic surgical urinary infection, the diagnosis of "chronic pyelitis" is usually made and of itself is as meaningless as the diagnosis of "laryngitis" or "cough" in pulmonary tuberculosis. While persistent pyuria may reflect only a chronic prostatitis for example, or pus in an improperly



FIG. 5. Infected (tuberculous) hydronephrosis secondary to tuberculous stricture of the lower right ureter. Two and a half years previously the opposite kidney had been removed for tuberculous pyonephrosis. There were advanced tuberculous vesical changes. Here the pyelogram is essentially the same as might be observed with calculus obstruction of the lower ureter.

collected specimen may originate in vaginitis, the very persistence of leucocytes in the urine despite intensive medical therapy (chiefly antisepsis) demands a complete urologic examination. This exploration often discloses chronic pyelonephritis and is generally complicated by or associated with infected hydronephrosis, ureteral obstruction, renal calculus, tuberculosis or malformation. In at least half of these cases the gastrointestinal function has been deranged reflexly or by urinary toxemia and the resulting diagnosis is chronic indigestion, intestinal indigestion, chronic appendicitis, cholecystitis, gastric or duodenal ulcer and flatulence. Focusing of the attention on the secondary alimentary manifestations commonly causes the basic urinary tract disease entirely to be over-

looked. Most urologic and chronic gastrointestinal surgical disease is not an emergency consideration. The patient should be given the advantage of at least an excretory urographic study when there is a doubt as to the diagnosis and before any abdominal exploration is carried out. If this is not satisfactory, an adequate urologic investigation is in order. If the urinary tract is normal, proceed with the gastrointestinal surgery. If the urinary tract is abnormal, eradicate the urologic disease first. An amazing number of patients said to have gastric or duodenal "ulcers," cholecystitis, chronic appendicitis, intestinal adhesions, and so forth, are relieved of these gastrointestinal symptoms by prostatectomy or other procedures which eradicate urinary obstruction.

INFECTED HYDRONEPHROSIS

The multiple causes of hydronephrosis are indicated in Figure 3, and the need for thorough urologic examination to identify the site and nature of the obstruction in any given case is at once apparent. In most instances the obstructive lesion is at the pelvic outlet or high in the ureter. Hydronephrosis, the commonest abdominal tumor in children, is usually congenital and is likely to be misdiagnosed as renal embryonal myosarcoma (Wilm's tumor). Mass and pain in the loin, often with hematuria, are the usual symptoms of hydronephrosis. With infection, there is pyuria. Infection added to hydronephrosis diminishes the chances of surgical renal restoration, and by the same token the need for nephrectomy is proportionately much greater in infected than in non-infected hydronephrosis. Urography, either excretory or retrograde, will demonstrate not only the gross pelvic changes but often the probable nature of the obstructive factor, e.g., stricture, calculus, aberrant vessel, kink and tumor. (Fig. 4.). In a young adult a polyp at the pelvic outlet obstructed and caused extensive hydronephrotic renal injury.



FIG. 6. Solid mass of dendritic stone (calcium phosphate which filled the right kidney pelvis of a girl who was examined because of mild "chronic pyelitis" (pyuria) of three months' duration. There were no other symptoms, but spontaneous fracture of the lower third of the left femur had occurred while running six weeks previously. This strongly suggested a calcium (parathyroid) metabolic error, but neither roentgen, skeletal studies, nor blood chemistry estimation (calcium and serum phosphorus) were confirmatory. Attempted pyelonephrotomy sufficiently damaged the kidney to require nephrectomy. A, plain urogram; B, retrograde pyelogram, showing how snugly stone fits in the calyces, pelvis and pelvic outlet.

PYONEPHROSIS

In pyonephrosis the kidney is destroyed by suppuration. This is usually the end stage of previously existing renal disease and notably infected hydronephrosis, stone or tuberculosis. Yet the infection terminating in pyonephrosis may be of sudden onset and massive, commonly caused by *Staphylococcus aureus* and hematogenous. In a short time the kidney is converted into a mass of parenchymal abscesses, chiefly cortical. This may become fatal if the nature of the condition is not promptly recognized and at once treated by nephrectomy. In this type the early clinical diagnosis is apt to be acute or persistent hyperacute pyelitis; in the more usual and more slowly developing varieties of pyone-

phrosis the usual and meaningless diagnosis is chronic pyelitis. Pyuria (often of the pea-soup variety), hematuria, pain and mass in the side suggest pyonephrosis, but the final diagnosis must rest on the urographic demonstration of the pelvic outline which frequently suggests the diagnosis of renal tuberculosis. (Fig. 5.) Yet in non-tuberculous pyonephrosis the secondary vesical inflammatory changes are meager as compared to those generally observed in the tuberculous variety. Chronic fibrotic changes in the lower ureter may render the duct rigid and its orifice held roundly open will present the so-called "golf hole." By complete urologic examination, accompanying calculus, obstruction or other disease will be demonstrated.



FIG. 7. Stone pyonephrosis in a young girl. A, large stone in pelvic outlet; multiple calculi in gallbladder (picture reversed); B, enormous massive hydronephrotic destruction of kidney, secondary to calculus obstruction; nephrectomy.

TUBERCULOUS RENAL INFECTIONS

Renal tuberculosis is never primary, is predominantly a hematogenous infection and when renal and osseous tuberculosis coexist, both are usually secondary to the same pulmonary focus. Fortunately, despite improvements in diagnostic technic, the reported incidence of renal tuberculosis has definitely declined during the past twenty-five years. Yet renal tuberculosis should be suspected in any patient with so-called cystitis existing more than a month. The demonstration of tubercle bacilli in the urine practically always means renal tu-

berculosis. Smegma bacilli will not confuse if the specimen for examination has been properly collected. Tubercle bacilli may readily be demonstrated in the urine in 80 to 90 per cent of the cases of renal tuberculosis simply by performing the usual acid-fast (steaming carbol-fuchsin) staining of the sediment of aseptically collected and centrifuged urine. The specimen is centrifuged at 2,500 revolutions per minute for fifteen minutes. Characteristically, tuberculous urine is acid, pale, contains albumin, pus, blood (microscopic or gross) and tubercle bacilli. Often there is mixed infection chiefly with *Bacillus coli*.

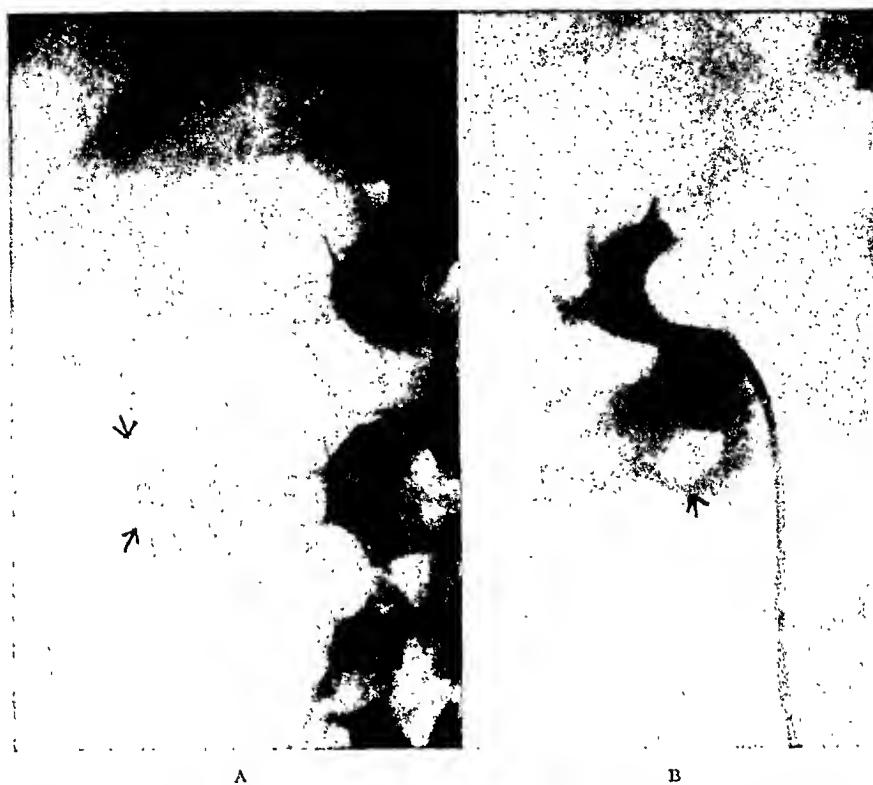


FIG. 8 A, stone of low radiopacity in right kidney pelvis. B, "negative" stone shadow in pelvis of kidney shown in A. The "negative" or vacuolization element is due to the relatively lesser radiopacity of the stone than of the radiopaque media; pyelolithotomy.

In the initial stages of renal tuberculosis, the disease picture is usually that commonly seen in chronic non-tuberculous pyelonephritis with pyuria, occasional renal pain; marked vesical irritability occurs early in over three-fourths of the patients. Painless spontaneous hematuria occurs in 5 to 10 per cent and frequently announces the disease. Its appearance signifies the rupture or erosion of a tuberculous lesion into the pelvis. Intermittent hematuria occurs in a fourth of these patients with renal tuberculosis, and is exceeded in incidence only by pain in the loin which is usually dull. Renal or ureteral colic is rare unless clot or calcareous caseous debris occludes the pelvic outlet of ureter. Fever is practically always present, low-grade, fluctuant or hectic and may reflect either the renal or the pulmonary tuberculous lesion or both. Excretory urographic studies will often suggest the diagnosis but we still prefer complete urologic studies with retrograde urography when the diagnosis is in

doubt. There is negligible danger in retrograde pyelography carefully and gently carried out and No. 4 catheters are employed. Free return flow down the ureter and about the small catheter precludes pelvic overdistention by the injected radiopaque media; we employ Skiodan. Unless the pelvic outlet or upper ureter are occluded by tuberculosis debris or sclerosis, and no urographic media can get through, the pyelogram will indicate renal tuberculous fibrosis, either local or widespread parenchymal ulceration, commonly with cavitation and heavy calcium infiltration, and sometimes perirenal tuberculosis as well. The correct differential diagnosis should be made early and it is particularly important to distinguish between renal tuberculosis and chronic non-tuberculous pyelonephritis. (Fig. 5.) The prospects of cure in renal tuberculous rest largely on early and correct diagnosis and prompt nephrectomy.

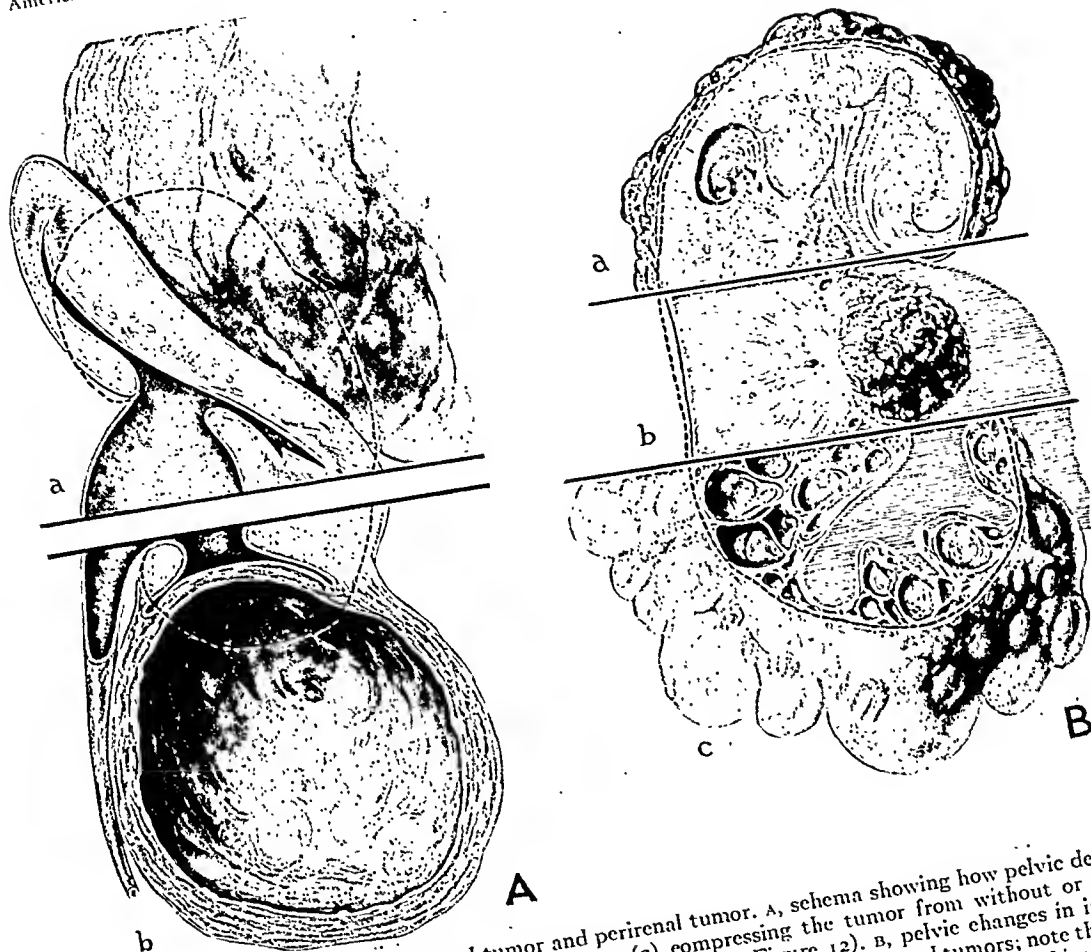


FIG. 9. Pycnographic findings in renal tumor and perirenal tumor. A, schema showing how pelvic deformity, compression or elongation results from tumors; (a) compressing the tumor from without or (b) from tumors arising within the kidney (e.g., here a cyst; see also Figure 12). B, pelvic changes in intrarenal tumors; (a) formation of "spider" pelvis by compression of growing parenchymal tumors; note the flattening and elongation of the calyces; (b) pelvic filling defect by papillomatous tumor; (c) bizarre pelvic irregularity and calyceal rounding seen in polycystic renal disease.

RENAL CALCULUS

Pain in the renal area or along the course of the urinary tract together with microscopic or gross hematuria and pyuria are the classic symptoms of renal calculus. The pain may be dull, intermittent or sharp colicky. Yet when the stone is large and immobile in the pelvis or is well enclosed in a renal segment, there may be no pain. This is the so-called "silent" stone. (Fig. 6.) Urography will establish the diagnosis of calculus in 90 per cent of the cases. (Fig. 7.) Pure uric acid stones cast no shadows but these and other relatively non-opaque urinary calculi can usually be demonstrated

as "negative" shadows in the excretory or retrograde urogram (Fig. 8) or as "positive" shadows in a pneumopyelogram in which air is injected rather than a radiopaque media. When renal pain exists, calculus is generally considered at once but in our observation complete examination commonly discloses the primary pain-producing condition more often to be chronic pyelonephritis, hydronephrosis or tumor. Gastrointestinal symptoms and disturbances are reflexly produced in a third to a half of patients with renal calculus disease, and often cause the diagnosis of appendicitis or cholecystitis to be made. Here

needless intra-abdominal operation is a common sequel and the result of failure to perform adequate examination of the patient.

RENAL TUMOR

In an adult painless fresh hematuria most often means tumor and in a child, nephritis. A mass simulating renal tumor may be produced by a number of conditions such as hydronephrosis and tuberculosis and establishment of the correct preoperative diagnosis will largely rest upon the urographic interpretation. Here retrograde pyelography is preferable to the excretory variety since changes in the finer pelvic markings are of paramount diagnostic importance and in renal tumor these changes are too often inadequately demonstrated by the excretory method. The pelvic outline in renal tumor is usually bizarre, displaced, distorted and with compression and elongation of the calyces, the characteristic "spider" type of pyelogram is obtained. (Figs. 9b and 10.) Yet in some instances the pelvic outline (tumor obstruction) suggests simple hydronephrosis, or there may even be a filling defect in the pelvic outline caused by papillary or polypoid growth. (Fig. 9b.) The diagnosis can nearly always be made promptly and upon this and early nephrectomy hinge the future hope for the patient's recovery.

RENAL MALFORMATION

Surgically the most important of the common renal anomalies are agenesis, hypoplasia, reduplication, ectopia, fusion, cystic (solitary, multiple, or polycystic) and abnormal mobility. In all of these conditions abdominal pain, a palpable mass or abnormal urinary findings direct attention to the urinary tract. Complete physical examination must necessarily include the genitalia and here it should be noted that in one of three patients with major deformities of these organs, the upper urinary tract is also anomalous. Ureteral and pelvic reduplication is the commonest anomaly observed but in seven clinical cases of



FIG. 10. Pyelogram in renal tumor showing distortion and displacement of kidney pelvis. Here the pelvis are not compressed as they commonly are found to be in renal tumors (spider type).

double uterus seen by Everette L. Campbell and me together or individually, there was unilateral renal agenesis. In four infants with double uterus seen at autopsy, there was renal agenesis and polycystic renal disease in one each and renal hypoplasia in two. The anomalous kidney is more prone to disease than a normal one. In all of these renal deformities the correct diagnosis can almost always be made by urography and when the excretory urogram is not thoroughly satisfactory and demonstrative, employ retrograde pyelography.

Congenital (or surgical) absence of one kidney should be recognized so that the solitary functioning kidney is not unwittingly removed as has been reported in a surprisingly large number of instances.

Aplasia of the kidney is of the same clinical importance as agenesis—the diminutive organ will not support life should

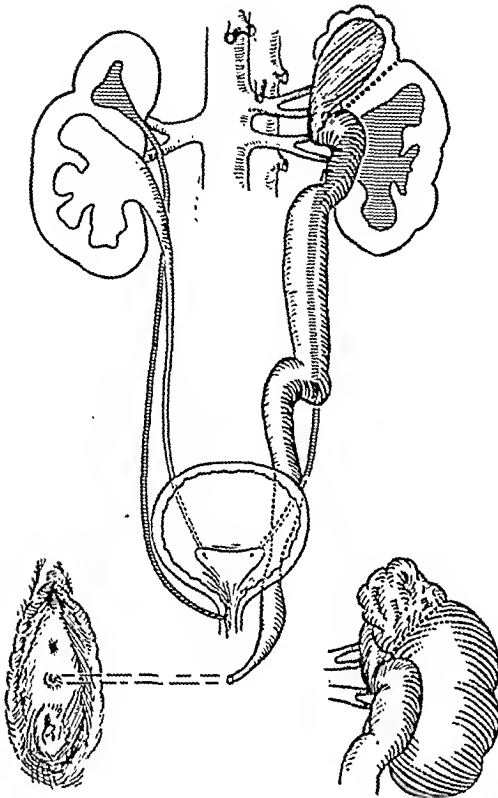


FIG. 11A.

FIG. 11. A, bilateral ureteral and pelvic reduplication with infected hydronephrosis of upper half of left kidney. Ureter from this pelvis opened ectopic in the introitus. Dotted line indicated line of renal resection. Symptoms were pain in the side and pyuria. B, pyelogram in A.



FIG. 11B.

the other kidney be removed. Hypoplastic kidneys are notoriously the site of pain and require removal. Pain is believed to result from compression of nerve endings by the contracting non-functioning nephrosclerotic tissue. Pyelography makes the diagnosis. The pelvis is small, infantile, and may be of the simple calyceal variety. Occasionally, the upper portion of the ureter to the diminutive kidney has no lumen or is a fine fibrous thread; this suggests agenesis rather than aplasia. Here surgical exposure will enable the anatomic distinction to be made. Yet this is usually of academic rather than clinical importance.

Renal reduplication occurs about once in 150 individuals. In most instances the malformation is of no moment but occa-

sionally half of the organ will be diseased by calculus, obstruction, suppuration and so forth. When this is demonstrated by urography, resection of the kidney with removal of the diseased segment will usually leave sufficient renal tissue to support life should the other kidney subsequently be lost. A satisfactory pyelogram is of utmost value to the surgeon as it will indicate the best line of incision with which to divide the kidney and not enter the pelvis. (Fig. 11.)

Ectopic kidneys are most often found in the lower pelvis where they are readily palpable and are likely to be thought to be abdominal or pelvic tumors. This has been the diagnosis in the several pelvic ectopic kidneys I have seen. Urography

establishes the nature and rotation of the ectopy and will indicate to the surgeon the length and course of the ureter should surgical elevation be desired.

Fused kidneys may assume bizarre shapes; the best known is the horse-shoe kidney in which there is either lower or upper polar fusion or complete fusion into one single mass. (Fig. 12.) Sometimes the lower pole of one kidney is fused with the upper pole of the opposite ectopic organ into S (sigmoid kidney) (Fig. 13) or L shapes. These fused kidneys are notoriously prone to disease, especially stone and infection, and since treatment and the resectability of the diseased segment will largely be indicated by urologic examination, a satisfactory pyelogram is of the utmost importance. A retrograde pyelogram is preferred. Abdominal pain, especially about the umbilicus, is often observed in abnormally formed kidneys, especially in horse-shoe kidney disease.

In *solitary cystic disease*, a dull ache in the side is the principal symptom and a mass in the loin is the usual finding. The pelvic outline as demonstrated by pyelography may be normal but it generally suggests tumor with compression of the kidney pelvis. (Fig. 14.)

In *polycystic renal disease*, the initial symptoms too often cause only the diagnosis of chronic interstitial nephritis to be made until or unless hematuria and pain in the loin occur or the bilateral renal masses are discovered. The pyelogram shows bizarre irregularity with a notable tendency to crescentic dilation of the major calyces. (Fig. 9B.) Sometimes the cortical cysts can be palpated through the abdominal wall.

The *abnormally mobile kidney* is likely to cause endless symptoms in nervous patients (renal pain, palpable mass, reflex gastrointestinal disturbance with pronounced psychoneurotic manifestations), but calls for no treatment unless there is ureteral obstruction. A good pyelogram is, therefore, of utmost value not only to make the diagnosis but to conclude whether



FIG. 12. Horse-shoe kidney disease in twelve-year-old girl who, because of persistent pain in the right upper quadrant, had been treated for several months under the erroneous diagnosis of gallbladder disease. During this time she had had eight cholecystographic series and three complete gastrointestinal radiographic studies. Excretory urography suggested the renal anomaly which was proved by retrograde pyelographic study (composite pyelogram shown above). Following resection of the horseshoe kidney through the isthmus with removal of the right half, the patient was entirely relieved of all symptoms, her digestion became normal and she gained weight. This case splendidly illustrates the close symptomatic interrelation between gastrointestinal and urinary tract disease.

nephro-ureterolysis and renal suspension are indicated. The urograms are made with the patient in the Trendelenburg position as well as upright in order that the degree of mobility of the kidney can be observed. To repeat, unless there is obstruction, operation should be withheld.

SUMMARY

From the foregoing it is readily noted that accurate preoperative diagnosis can be made in surgical renal disease and here pyelography is indispensable. By recognition of (1) the high incidence of urologic disease as the cause of abdominal symp-



FIG. 13. Crossed fused renal dystopia in girl examined because of chronic pyuria and intermittent pain in the right loin. During an acute attack of the latter, a normal appendix was removed. The urogram indicates a variety of pelvic misdirection commonly observed in this condition. There is some dilation of the ureter which drains the upper renal pelvis (congenital ureterovesical junction stricture). This stricture readily responded to therapeutic dilation.



FIG. 14. Large solitary renal cyst involving the lower pole of the right kidney. There is marked pelvic distortion and compression with transverse flattening of the lower calyx (compare Figure 9A). Excision of the cyst with scissors with complete removal of the cyst lining is simple, curative and conserves the remainder of the kidney.

toms, (2) the facility with which the renal diagnosis commonly can be made, it is at once apparent that no patient with vague and indistinct abdominal pain should be subjected to laparotomy without at least the benefit of a satisfactory excretory

urographic study. If this dictum is recognized, more cases of "abdominal adhesions," "chronic appendicitis" and the like will become bona fide instances of renal or ureteral disease and usually will be characterized by obstruction.



ACUTE SURGICAL LESIONS OF THE PELVIS*

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UNDER this topic I would place six main headings and attempt to discuss them without going into too much detail.

Acute Salpingitis. This may or may not be of specific origin but usually is specific and is due to Neisserian infection. The status of the treatment of this disease has almost completely swung from a surgical approach to a medical one, especially since the introduction of the sulfa drugs and the more recent, almost specific, penicillin. There remains, however, about the same relative number to be treated surgically as were treated medically fifteen years ago, which is almost a complete reversal of trends. That, of course, is all to the good as regards the patient. It certainly was not pleasing to the surgeon to have to make it impossible for conception to take place for so many female patients in their early twenties. Now the tables have turned. Someone has said gynecologic surgery is on the way out.

The diagnosis of this disease is usually not difficult, especially if a careful history is taken, and uterine cervical and Skene's gland smears are made. One must also bear in mind that most acute infections of this kind are apt to become active immediately after the menses. Surgery is only indicated after rest and the free use of the sulfas and penicillin. The surgical indications need only *then* be faced and conservative surgery would be dependent upon the social status of the patient.

Extra-uterine Pregnancy. This presents problems in diagnosis and therapy which are often very difficult. A clear classical case in which there is a history of the patient's being one to four weeks overdue in menses, with every other indication of

pregnancy, then sudden acute abdominal pain with distress in the pelvis and frequently pain in the diaphragmatic area, is not difficult of diagnosis. But when even these symptoms occur before menses are due, or at the time menses are due, they present problems sometimes hard to evaluate; but, with definite pain, signs of hemorrhage and increased white count, one is justified in opening the abdomen for exploratory purposes. Even during exploration the signs may be so scant as to present a real problem, that is, when a very early pregnancy is attached to an ovary. A more difficult problem is to differentiate between a ruptured extra-uterine pregnancy and a tubal abortion. If the latter is present, surgery may not be indicated. I am sure many such extra-uterine abortions have healed of themselves without surgery.

Ruptured Corpus Luteum Cyst. Ruptured ovarian cysts may be divided into two types: the hemorrhagic and the ruptured simple cyst. In the hemorrhagic type, the symptoms are largely those of severe shock with signs of hemorrhage, and are often hard to differentiate from those of extra-uterine pregnancy. The symptoms of rupture of the simple corpus luteum cyst are often confused with those of acute appendicitis. There are several points to be emphasized, however. The pain of a ruptured cyst is very severe and sudden, often occurring on a shopping tour or card party. The history should tell one whether the time of sudden pain is about midway between menstrual periods. Occasionally, the patient is operated upon at once by the "eager" operator, only to find, instead of a ruptured appendix, an accumulation of a straw-colored fluid in the pelvis or a ruptured corpus luteum cyst. For-

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tunately, acute hemorrhage is seldom present. Greater care in eliciting a history will save the surgeon some embarrassment.

Acute Appendicitis. One should be able to differentiate its symptoms from those of other acute pelvic lesions except when the appendix attached to a loose low-lying cecum (often seen in patients with enteroposis) lies posterior to the uterus or in the cul de sac of Douglas. In this type of case one may find an acutely inflamed appendix, even a ruptured one, lying in the cul-de-sac of Douglas and resembling on examination the findings of acute salpingitis, except that the inflamed tumor mass is not bilateral as in most cases of acute salpingitis. Fortunately, nature is usually good to such a lesion by walling off the appendix, and if the diagnosis plus surgery are delayed, no hazard is added by the delay. If one should encounter pus, drainage through the cul de sac is readily and safely done.

Twisted Ovarian Cyst. This alone or complicated by other chronic pelvic conditions, will at times present a problem, and again a delay of twenty-four to forty-eight hours in making a diagnosis entails no

undue hazard to the patient. Surgery, of course, is always necessary.

Necrotic Myoma of the Uterus. Acute necrosis of a myoma of the uterus or the twisting of a pedicle of a myoma presents a diagnostic problem, even though signs of local tenderness may not be present; but surgery is indicated eventually and offers a safe and prompt solution.

There are other pathological lesions in the pelvis, but of such rare occurrence that they will not be mentioned. They so often complicate the main problems just mentioned, that surgery for one condition will remedy the other.

Thus one sees that there are many real challenges in making an accurate diagnosis of acute conditions in the pelvis. Certain it is that the advent of the sulfonamides and penicillin have averted surgical intervention and saved many a reproductive organ from a trip to the pathologist's table. A detailed history of premonitory and immediate symptoms is of the greatest value in a proper diagnosis. The technical details of surgery present no great problem to the average surgeon.



THE TREATMENT OF ACUTE PERFORATION OF DUODENAL ULCER

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THIS communication records the details of the management of 130 consecutive cases of acute perforation of a duodenal ulcer admitted to the First Surgical Division of the Toronto General Hospital since July 1, 1929. This critical analysis has confirmed the soundness of the previously published principles (1)² which have guided our therapeutic procedures in the management of this grave emergency. This study excludes all cases of perforated gastric ulcers. Our experience with such emergencies has been small, operation in many instances revealed that the perforation had occurred through a gastric carcinoma. A subsequent presentation is planned to assess the ultimate fate of this group of perforated duodenal ulcers. We concern ourselves at the moment with the management of the emergencies.

TABLE I

Total Cases.....	130	D.....	13
Cases No. 57 & No. 98....	2	refused operation	
Cases No. 104 & No. 128..	2	moribund—no operation	
Case No. 76.....	1	undiagnosed	

Total not operated.....	5		
Total No. of operated patients.....	125	D....	8 = 6.4 per cent

Deaths

1. Case No. 48—Pulmonary embolism. Autopsy 10th day
2. Case No. 67—Pneumonia
3. Case No. 79—Pneumonia + Senility
4. Case No. 72—Pneumonia + Mild peritonitis
5. Case No. 78—Uraemia
6. Case No. 80—Unrecognized pelvic abscess—perf., general peritonitis
7. Case No. 102—Subphrenic—undiagnosed—perforated to bronchus
8. Case No. 126—Multiple pulmonary abscesses—Subhepatic abscess—Chronic Osteomyelitis Femur + Pyelonephritis.

A reference to Table I will show that of this total group of 130 cases there were

thirteen deaths. Five patients were not operated upon; two refused operation; two were moribund on admission and their condition could never be improved to a point where it was justifiable to advise operation; one patient died before the diagnosis was made, despite the fact that he was in the hospital for two weeks. At autopsy it was found that an unrecognized left subphrenic abscess had perforated into his bronchus.

One hundred twenty five patients were operated upon with eight deaths, an operative mortality of 6.4 per cent. The details of the deaths are presented in Table I. Three predominant areas are responsible for the fatality, chest, subphrenic space and the pelvic cul-de-sac. There were three patients in whom pneumonia was a factor responsible for death. In one it was the sole factor, in a second it was part of a general senility and in a third it was complicated by a mild peritonitis. It was considered at autopsy that the actual cause of death was the pneumonia, as the peritoneal reaction was minimal; two patients had undiagnosed subphrenic abscesses. One perforated into a bronchus similar to that which occurred in the non-operated undiagnosed case. The other case presented multiple pulmonary abscesses, multiple intraperitoneal abscesses, pyelonephritis, as well as a subphrenic abscess. This patient had a coincidental chronic osteomyelitis of the femur. While it is impossible to prove irrefutably that the widespread infection was metastatic from the chronic discharging osteomyelitis, this seems the most logical explanation of the dissemination of his infection. One patient died of a pulmonary embolus on the tenth day; autopsy showed that the operative site was normal.

We are impressed by the infrequency of emboli and peripheral vascular accidents postoperatively since we have been practising early ambulation. It is too soon to be absolutely certain of the rôle which early ambulation is playing in the diminution of postoperative vascular accidents. It is a fact that coincidental with this practice there has been a very sharp reduction in the incidence of these complications. During this same period extreme care has been taken in the preoperative and postoperative management of our surgical patients, particularly in regard to the correction of their nutritional and biochemical defects. This management, as well as early ambulation, is a contributing factor to the diminution of the postoperative complications.

It is interesting to note the age incidence. There were seventy-two patients aged fifty years or over and fifty-eight were forty-nine years old or younger, with an average age of forty-eight and one-half years. However, in the wide spread of the age group, the youngest patient was sixteen years of age and the oldest was eighty-three, so that age as a factor in the diagnosis is perfectly useless. It is possible, however, to have helpful information by considering the ratio of males to females. There were 123 males and seven females in the group. This fact has warned us against the snap diagnosis of a perforated duodenal ulcer in women. When we suspect this as a possible diagnosis, the infrequency of its occurrence is sufficient to demand that we canvas every other alternative diagnosis before accepting it as the cause of the patient's illness.

The diagnosis of an acute perforation of a duodenal ulcer is not difficult in most cases, nevertheless we have made errors. These errors have arisen from the difficulty in differentiating an acute perforated ulcer from acute appendicitis, acute pancreatitis and acute cholecystitis, in diminishing order of frequency. Only a small percentage of the patients with an acute perforation of a duodenal ulcer fail to give a history of previous gastrointestinal distress. If a patient whose signs and symptoms present

diagnostic difficulty has had a long continued indigestion of the duodenal ulcer type, with major and minor periodicity, it is surprising in what a large percentage of these patients there has been an acute exacerbation in the intensity of their distress just prior to the perforation. This is not true in patients who suffer from acute appendicitis, acute pancreatitis or acute cholecystitis.

The estimation of the serum amylase in all patients who suffer from indefinite, sudden abdominal pain we have found to be of great value in confirming or excluding the presence of acute pancreatitis. We have found invariably in all cases of acute hemorrhagic pancreatitis that the serum amylase has been elevated. This finding has reduced the incidence of errors and confusion in the diagnosis of acute pancreatitis.

Atypical appendicitis, however, presents the greatest diagnostic confusion. One patient was operated upon five hours after the onset of the pain, diagnosed as a perforated duodenal ulcer. He had a perforated appendicitis in an imperfectly descended cecum, the appendix lying in contact with the duodenum. The character of the original pain in acute perforation of a duodenal ulcer is of value in differentiating this emergency from extraperitoneal lesions with which it may be confused. A sudden coronary occlusion is often associated with very severe abdominal pain, but this gradually increases in severity, and permits the patient to reach a place where he can comfortably rest; whereas a patient who has a sudden perforation of a duodenal ulcer is as a rule suffering a pain so sudden, severe and crippling as to immobilize him for a varying period of time, often as long as an hour. The coronary pain is usually persistent, or increased in a crescendo, while the pain of a perforated duodenal ulcer usually diminishes until at the end of one or two hours there occurs the tragically dangerous so-called "latent period," in which the patient is reasonably comfortable while lying still, and pulse and temperature are normal. However, on physical examina-

tion true rigidity of the abdominal muscles is always present. This true rigidity is differentiated from the false rigidity due to fear or extraperitoneal lesions by the fact that in true rigidity the tension in the muscle is constant during the entire respiratory cycle, whereas if it be a voluntary or false rigidity there is a momentary relaxation at the end of inspiration. This finding is tremendously important. True abdominal rigidity as an accompaniment of an acute hemorrhagic pancreatitis is extraordinarily rare. If in addition to the abdominal pain there is a pain referred to the shoulder tip, we have evidence of diaphragmatic irritation, which can be confirmed by a flat x-ray plate taken in the erect position, which will show the presence of gas under the diaphragm. While gas is not always present under the diaphragm, it is of inestimable diagnostic value when demonstrated by x-ray examination. The absence of gas under the diaphragm is of no diagnostic value. It was not noted in seven consecutive cases of perforated ulcers. The loss of liver dullness as elicited on physical examination by percussion of the abdomen, may be misleading. We have found that the normal area of liver dullness may be obliterated by distension of the colon. Hence the absence of this area of dullness does not necessarily indicate that free gas is present in the peritoneal cavity.

Until May of this year we had never seen a patient suffering from a perforated duodenal ulcer who did not have a leucocytosis. This patient on admission had a white blood count of 3.4. On the fifth postoperative day it had risen to 4.0 and on the sixth postoperative day was 11.2. The bacterial study of this exudate showed it to be the result of a pure culture of pneumococcus. A previous communication³ has stressed a trinity of signs and symptoms as indicative of intraperitoneal irritation. The acceptance of this trinity as evidence of an intraperitoneal abnormality has become increasingly justifiable with its increasing use. The trinity is (1) The asso-

ciation of pain and tenderness. If the patient complains of pain without being also tender in the same area, the lesion is extraperitoneal. This is the most valuable single evidence in differentiating intra- from extraperitoneal lesions. (2) One point of maximum tenderness. The patient will put his finger on a point rather than place the whole hand over an area to indicate the site of his distress. (3) It hurts the patient to roll over in bed. If in a patient who is complaining of abdominal pain, this trinity of signs and symptoms is present then such a patient has an abnormality within the peritoneal cavity. This trinity may occur as the result of free blood in the peritoneal cavity; excluding this it is due to an acute inflammatory lesion.

If in association with this trinity rebound tenderness is present, it is inconceivable that the patient has a normal peritoneal cavity. Rebound tenderness is elicited by suddenly releasing the palpating hand which had been pressed firmly on the abdominal wall. This sudden release of pressure is accompanied by sudden abdominal pain if rebound tenderness is present.

If after a careful assessment of the data elicited by history analysis, physical examination, x-ray and laboratory studies, the diagnosis is still in doubt only as to the cause of the intraperitoneal catastrophe, the site of the incision must be determined. Under such conditions we always explore the peritoneal cavity through a gridiron incision in the right iliac fossa. This incision is atraumatic and harmless and almost invariably will solve the diagnostic problem. Should the lesion be an acute appendicitis, the operation may be performed through it. If on the other hand, the patient, should be suffering from a perforated duodenal ulcer and not from appendicitis, it is important to recognize and differentiate a peri-appendicitis from a true appendicitis.

Following the acute perforation of a duodenal ulcer, the inflammatory exudate and duodenal content flow down along the right colic gutter, resulting in the pro-

duction of an inflammatory reaction about the appendix. However, to recognize this type of reaction as a possibility is sufficient to avoid an error in mistaking the local lesion as being the result of a true acute appendicitis.

It is obvious that under such circumstances a second incision is imperative to give access to the perforated ulcer. It is not necessary to apologize for this. Such a sequence is infinitely safer, less traumatic and accompanied by fewer postoperative hernias than if one explored the duodenum for a suspected perforation and then had to enlarge the incision sufficiently to enable the removal of an acutely inflamed appendix.

Having accepted the diagnosis of an intraperitoneal catastrophe, one then must define the surgeon's responsibility in an emergency abdominal operation. The only justification for doing an emergency abdominal operation is that to defer such a procedure would endanger the patient's life. Thus many operations will have to be undertaken at inopportune times in an inadequate environment, with the staff and facilities available: therefore, the surgeon who is readily accessible to perform the operation is the best surgeon to close an acute perforation of the duodenum. The operation which will be proposed is so simple that it can be done by any medical man who has had even a modest training in surgical technic. There is no justification for debating the wisdom of a gastroenterostomy or a gastric resection. As a corollary, it is unwise to transport a patient suffering from an acute perforation of a duodenal ulcer over long distances if there is anyone available locally who can carry out the necessary operative procedure. The operation should be one that confines itself solely to dealing with the lesion responsible for the emergency and dealing with it efficiently in the most simple manner. It is obvious, in a patient who requires operation for an acute perforation of a duodenal ulcer, that the prime requisite is the closure of the perforation. We

must, therefore, answer the question: What closes all perforations in the gastrointestinal tract, even those that are inevitably made in the performance of abdominal operations requiring gastrointestinal anastomoses? While theoretically a needle may be inserted in the gastrointestinal tract in the performance of anastomoses without entering the lumen, this probably rarely occurs. If one could examine microscopically the course of the needle and its suture, it would frequently transverse mucous membrane. However, despite this, successful anastomoses are possible because as a result of even the minimal trauma of such a suture, there is sufficient tissue damage to produce fibrin ferment, which will result in the formation of fibrin from the inevitable inflammatory exudate which accompanies all wound healing. Thus we must remember that fibrin is the substance which seals all perforations in the gastrointestinal tract. Therefore, any operation which will result in the gross production of fibrin would be an ideal operation to utilize in closing a perforated duodenal ulcer.

Having accepted this philosophy of the surgeon's responsibility in the performance of an emergency abdominal operation, an oft-quoted aphorism states, "The sun must never rise nor must the sun ever set before a patient who is suffering from an acute perforation of a duodenal ulcer is operated upon." This statement is completely erroneous. It is founded on the belief that the patient is always sick because of a bacterial peritonitis. This is incorrect in almost all instances. In sixty-five patients on whom culture was taken, thirty-four were sterile; thirty-one showed organisms of various kinds and only six grew pathogenic organisms from the peritoneal exudate. One was a pure culture of typhoid;⁴ one *Streptococcus hemolyticus*; one *pneumococcus* and only three grew colon bacilli. That infection is not such a "bete noire" as is commonly believed is supported by the fact that of the eight operative deaths only four, or 50 per cent of these deaths had an associated peritoneal infection, and indeed

in two of them the peritoneal infection probably was a minimal factor in their terminal illness.

What then is responsible for the disastrous clinical state in which we find these patients? The following case is typical of many, and supports the thought that pain, nutritional defects and biochemical imbalance are the determining factors in the patient's clinical state:

A male, aged fifty-five, was admitted to the Department of Medicine for investigation of an indigestion which previous admissions had failed to identify as due to structural disease. He previously had had many operations and recently had complained of frequent abdominal pain. During his hospitalization for investigation, at 6 A.M. he suffered sudden epigastric pain associated with abdominal tenderness and muscular rigidity. When seen in consultation he was desperately ill; his blood pressure was 75/50. The diagnosis of a serious intraperitoneal catastrophe was made most likely the result of an acute perforation of a duodenal ulcer. X-ray showed no free air under the diaphragm. His general condition was so poor that immediate operation was considered unwise. He was placed in an oxygen tent, pain was relieved by sedatives, and intravenously he was given by the drip method 1500 cc. of saline and glucose, as well as 500 cc. of plasma and 500 cc. of whole blood. At the end of ten hours his blood pressure was 110/76 and his pulse 80. His appearance and general condition were in marked contrast to that when first seen. At operation a perforated duodenal ulcer was found, and *cultures taken from the intraperitoneal exudate were sterile*, despite the fact that operation was not undertaken until sixteen hours after the perforation, ten hours of which were consumed in the preoperative preparation. He made an uninterrupted convalescence.

This case is not unique in the series, but specifically presents evidence which refutes the thought that a bacterial peritonitis is responsible for the serious clinical state which is so often an accompaniment of an acute perforation of a duodenal ulcer.

A plea is made for a careful assessment of the patient's nutritional state and biochemical balance before any operation is

undertaken in cases of acute perforation of a duodenal ulcer. During the years in which this attitude has guided our preoperative management of such patients we have become convinced of the soundness of this regimen. The transformation of a seriously ill patient from what appeared to be a desperate if not a fatal illness to a clinical state where operation could be safely undertaken represents one of the thrills of a surgical career.

Thus we accept the following criteria as sufficient to justify delaying operation in order to improve the clinical state: (1) A severe nutritional disturbance, which can be gauged by the diet taken immediately preoperatively; (2) severe dehydration, (3) severe anemia and (4) a low blood pressure, rapid pulse, severe abdominal pain, as a part of the general picture of shock. Patients now, instead of being admitted directly to the operating room are always sent to the ward, where their clinical state is assessed carefully. It is surprising how the intravenous administration of fluids, with heat, sedation and oxygen, will improve most patients in a very few hours. We have never regretted the time consumed in this preoperative preparation, despite the fact that we are very conscious that it is deferring the operation.

The operative procedure, which is in most instances performed by the resident or senior interne, is carried out under spinal anesthesia. This type of anesthesia we are convinced has great advantages over the inhalation anesthesia. The abdomen is still, in marked contrast to the plunger action of the diaphragm and liver in deep inhalation anesthesia, which action has been shown by Gordon to disseminate the intraperitoneal exudate. Gordon³ in a series of dogs, introduced India Ink into an area in the peritoneal cavity. One group was anesthetized with spinal anesthesia. The second group was anesthetized with inhalation anesthesia. The dissemination of India Ink throughout the peritoneal cavity was infinitely more diffuse in the latter than in the former group.

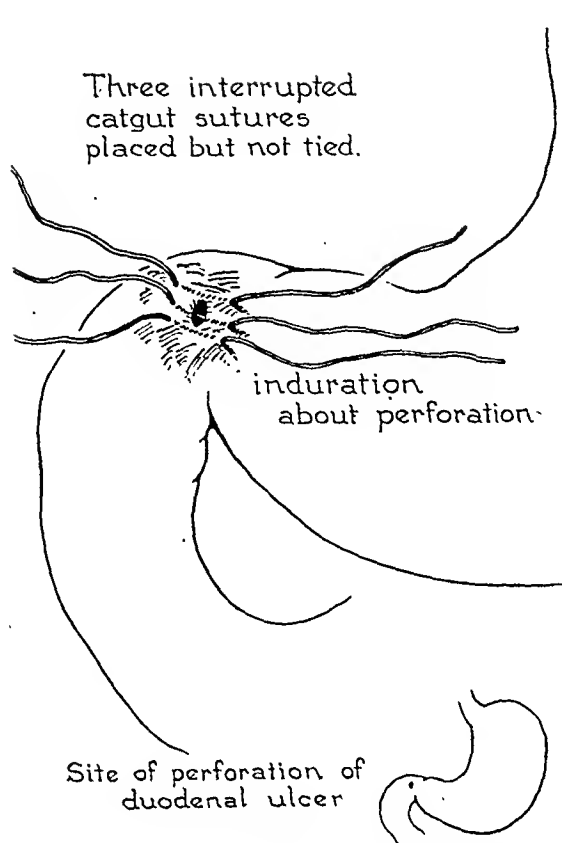


FIG. 1. The sutures placed in relationship to perforation.

The basis of our operative procedure is the gross production of fibrin. Traumatized tissue will liberate the necessary ferments to stimulate the production of fibrin from an inflammatory exudate. On many occasions when operating for chronic duodenal ulceration, omental or fat tags were adherent to the base of a duodenal ulcer. This we interpreted as a control of minimal perforation. For many years we had used omental and fat grafts to cover raw areas of bowel in secondary operations and to close the ureter and common bile duct after the removal of calculi. It seemed logical that such a maneuver would adequately seal the perforation of the duodenum. Repeated operations have proven that such is true. We aim now to place a piece of adjacent fat or omentum attached or free over the perforation and hold it in place with sutures.

The abdomen is opened through the right rectus muscle and the fibrin leads the surgeon to the site of the perforation. Two types of duodenal ulcers perforate, one, the

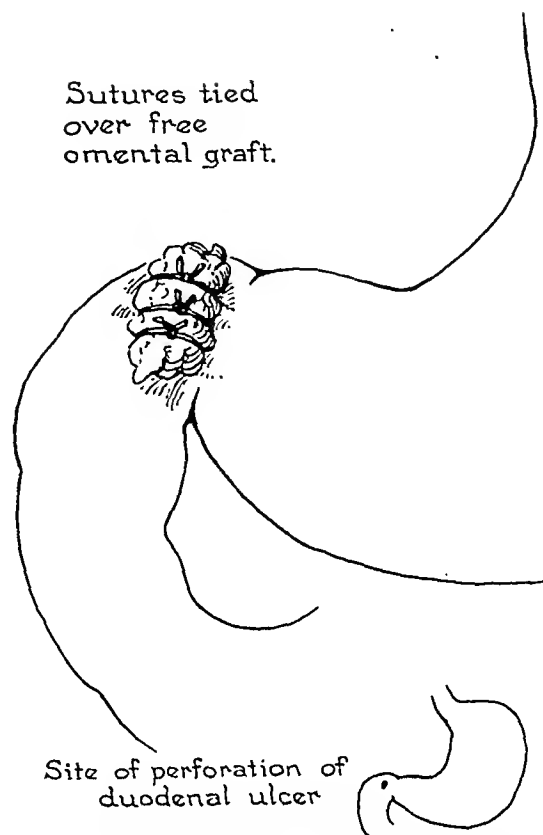


FIG. 2. Sutures tied holding omental graft in position. They are tied only tightly enough to hold the graft with no attempt to approximate the sides of the perforation.

acute variety, with a cleanly punched out hole in the duodenal cap, with no induration about it. The other is a perforation in a rigid mass of scar tissue in and about the duodenal cap. While it might be possible to close the acute ulcer, all have experienced the futility of attempting to close by suture the perforated indurated ulcer. It can, however, be efficiently closed. Three sutures are placed parallel to the long axis of the duodenum, one above, one across and one below the perforation. (Fig. 1.) A piece of fat or omentum free or detached is placed over the hole and the sutures are tied only tightly enough to hold the fat or omentum in position, with no thought that the tied sutures will approximate the margins of the perforation. Within an incredibly short time the area is covered with a thick layer of fibrin. During the war ample opportunity was available to see how rapid and how gross was the formation of fibrin about penetrating wounds of the gastro-

intestinal tract. Lewis¹⁰ has shown that the intraperitoneal exudate in these cases contains trypsin. For this reason the excess exudate may be removed with a sucker. However, it is not necessary to be so vigorous in its removal as to prolong the operative procedure unduly or traumatize the peritoneal contents.

In view of the bacteriological studies of the intraperitoneal exudate, the abdomen is closed without drainage. We are impressed with the efficacy of using No. 32 stainless steel wire as suture material. Interrupted figure-of-eight sutures as advocated by Jones⁷ are used. The patient is returned to bed with an indwelling Levine tube inserted through the nostril, and if seriously ill is placed in an oxygen tent for twenty-four to forty-eight hours. Fluid is allowed by mouth in volume of one ounce at a time every half hour if the patient desires it. Fluid and chemical balance is maintained by the intravenous administration of water, salt, glucose, plasma or whole blood as indicated. The adequate and easily recorded control of fluid balance is made possible by the use of a fluid balance sheet. (Fig. 3.) In the immediate postoperative period the edema about the ulcer obstructs the pylorus and unless great care is taken to replace fluids and electrolytes aspirated from the stomach the patient can rapidly reach a state of hypochloremia, or even go into gastric tetany. However, many complications are avoided if the stomach is kept empty with the indwelling Levine tube and fluid and chemical balance is maintained.

POSTOPERATIVE MANAGEMENT

The immediate convalescence of these patients has been delightfully uneventful, with rare exceptions. In this whole group we have had two duodenal fistulas. These can be dealt with safely and adequately, using Potter's technic.⁸ The last case occurred in the patient previously discussed who had the low leucocyte count of 3,400 at the time of operation and whose peritoneal exudate showed a pure culture of

pneumococci. This combination was a definitely contributing factor in the formation of this fistula. The principle of Potter's technic is based on the fact that if one can acidify the alkaline duodenal secretion and provide for its disposal on the abdominal wall, there will be prompt healing and with a minimum skin excoriation. To accomplish this a small catheter is placed as far into the fistulous tract as possible and N/10 hydrochloric acid is dripped through this catheter at the rate of approximately 25 cc. an hour. A further tube is placed just at the fistulous opening in the skin, and suction applied. Gauze soaked in 10 per cent commercial peptone then is applied as a dressing around the fistulous opening, and this provides a substitute for the skin to be digested by any unneutralized ferments. The last fistula was healed within ten days from the instituting of this management.

Three areas should always be canvassed carefully if the patient's postoperative progress is not satisfactory: (1) the chest, (2) the pelvic cul-de-sac, and (3) the subphrenic area. One patient we probably could have saved had we done a rectal examination with greater diligence. We would have recognized a pelvic abscess, which subsequently ruptured into the peritoneal cavity. We have in all abdominal cases made it a rule for years always to pass a Levine tube and always do a rectal examination on every patient whose postoperative course is causing us the slightest concern. The assistance of our medical confreres is invaluable in the diagnosis of subphrenic space infection. Even when one suspects it, it is a most difficult diagnosis, as has been shown by Warner and Doidge.⁹

There is one pitfall in the diagnosis of subphrenic space infection. If during the investigation of such a patient x-ray studies show gas under the diaphragm, one should not accept this as evidence of a subphrenic abscess if the patient were operated upon with a spinal anesthesia. Lewis⁶ has shown that in all patients whose abdomen is opened under spinal anesthesia

FLUID BALANCE SHEET													
The data indicated to be recorded on all cases having an indwelling duodenal or Miller-Abbott tube or to whom an intravenous solution is being given. All amounts to be recorded in cubic centimetres. All totals, all losses or gains, and all Transfusion Volumes to be recorded in red ink. Indicate any reaction by the letter "R" in red ink in the appropriate horizontal column under "intravenous."													
NAME	DATE	WARD OPERATION											
		7 A.M.-7 P.M.	7 P.M.-7 A.M.	7 A.M.-7 P.M.	7 P.M.-7 A.M.	7 A.M.-7 P.M.	7 P.M.-7 A.M.	7 A.M.-7 P.M.	7 P.M.-7 A.M.	7 A.M.-7 P.M.	7 P.M.-7 A.M.	7 A.M.-7 P.M.	7 P.M.-7 A.M.
Fluid Intake Per os.													
Intravenous Saline													
5% glucose in normal saline													
5% glucose in distilled water													
Blood													
Plasma													
Total intake													
Fluid Output Fistula													
Stool													
Tube													
Vomitus													
Urine													
Total output													
Total Intake Gain													
Loss													
Gastric Intake Gain													
Loss													

FIG. 3.

air is locked under the diaphragm and it may persist for as long as six weeks.

CONCLUSIONS

1. A series of 125 consecutive operations for acute perforation of duodenal ulcer is presented, with eight deaths, a mortality of 6.4 per cent.

2. The cause of the patient's serious clinical state following perforation of a duodenal ulcer is not the result of a bacterial peritonitis, but rather the result of nutritional and biochemical imbalance associated with the phenomena of shock.

3. Adequate correction of these disturbances before undertaking the operation contributes the greatest safety factor in decreasing the mortality of this catastrophe. We have never regretted the time consumed to achieve this.

4. An emergency abdominal operation should deal in the most simple manner solely but effectively with the lesion responsible for the emergency. Gastroenterostomy and gastric resection have no place in this management.

5. Fibrin is responsible for the closure of all gastrointestinal perforations. A free or attached omental graft held in position over the perforation by three sutures re-

sults in the gross formation of fibrin to close the perforation.

6. Drainage of the abdomen at the time of closure of the ulcer is unnecessary.

7. The intraperitoneal use of sulphanilamides appears to be superfluous.

8. Spinal anesthesia is the anesthesia of choice.

9. Should a postoperative fistula occur, Potter's technic is efficient.

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THE SURGICAL TREATMENT OF CHOLECYSTITIS*

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FROM the surgical standpoint, cholecystitis may be properly divided into two phases, according to the pathologic process: (1) The chronic phase and (2) the acute phase. The present discussion will be devoted to a consideration of the most salient features of the disease, particularly in relation to these two phases.

Chronic Cholecystitis. By far the majority of patients with this type may be successfully treated by medical measures. The question is: At what point does surgical treatment become necessary for the remainder? Aside from the mortality, which is comparatively low, approximately 15 per cent of patients with chronic cholecystitis are unimproved or made worse by operation. These poor results may be attributed largely to errors in the selection of patients for operation, especially those who have the noncalculous form of the disease. Many errors might be avoided by observance of more rigid criteria for surgery, and this in turn is made possible by more penetrating inquiries into the patient's complaints and more exhaustive examinations.

A simple approach to this problem may be found in the classification of patients with gallbladder disease into three groups: (1) Those who have digestive disturbances but no colic, (2) those who have colic but no digestive symptoms, and (3) those who have both colic and digestive symptoms.

In studying patients of the first group, one must determine whether the digestive symptoms are in reality related to disease of the gallbladder or to some other disturbance. One may likewise be called upon to evaluate such vague manifestations as exhaustion, insomnia, dizziness, pains and aches in and about the muscles and joints, and headaches, all of which are common to toxic conditions of various origin. Again, the patient may describe symptoms re-

sembling those of duodenal ulcer. If, as occasionally happens, a duodenal ulcer is also present, a proper classification may be practically impossible.

Especially is confusion likely to arise in the differentiation from appendicitis. Right iliac pain is not uncommon in cholecystitis and, on the other hand, a high lying inflammatory appendix may be mistaken for an infected gallbladder. This fact, and the fact that the two diseases are frequently associated calls for a fine interpretation of all the symptoms and signs and the use of all the diagnostic measures at our disposal.

Patients of the second group, i.e., those with upper abdominal colic but no digestive symptoms, should be studied not only for disease of the gallbladder, but for disturbed liver function, disease of the pancreas, a gastrointestinal infection or angina pectoris. If the gallbladder is the offender, stones will usually be found and a penetrating history will reveal that the patient has had a mild disturbance for several years, or perhaps an early period of severe symptoms followed by a period of comparative quiescence. Epigastric colic, however, is frequently associated with non-calculous cholecystitis, the causative agent being pericholecystitis, spasm of the gallbladder and ducts and of the sphincter of Oddi, or some type of mechanical obstruction outside the ducts. When the colic begins as a mild ache and is associated with a digestive disorder, one should immediately suspect cholecystitis.

Some light may be thrown on the various diagnostic problems of gallbladder disease by gastric analysis and duodenal drainage. The latter is most valuable as a means of studying the concentration and emptying function of the gallbladder. More important, however, is the roentgenographic study, without which no examination is

complete. The demonstration of a poorly functioning organ in a patient who presents symptomatic evidence of cholecystitis is ample indication for surgical interference. On the other hand, poor function alone may be of nervous or other origin and thus is not sufficient reason for operation.

Regardless of the roentgenographic picture, when the symptoms of cholecystitis are clear cut, severe and persistent, operation is advisable. The roentgenogram is not always a dependable means of determining the true pathologic condition; even in well established cases of cholecystitis, including those with stones, it occasionally fails to reveal either stones or a marked alteration of function.

There is no question as to the necessity for operation when stones are demonstrated. The vast majority of these patients give a history of colic and many of them report having had some degree of jaundice. Even though the symptoms may be mild and the function of the gallbladder appears little altered or not at all, it is the better part of wisdom to rid the patient of this source of trouble, as a precaution against an acute catastrophe. Another possibility to be borne in mind is that of malignancy. Carcinoma of the gallbladder and ducts is relatively rare, yet it is significant that stones are found in almost every case.

From pathologic studies made in an effort to determine which type of chronic cholecystitis is most amenable to relief by surgery, it appears that removal of the thick walled gallbladder with stones and associated cholesterosis (the "strawberry" gallbladder) practically always affords complete relief, provided the liver and other organs have not been too severely damaged. The next best results are obtained following cholecystectomy for simple cholecystitis with stones and, finally, following removal of the non-calculous gallbladder with extensive inflammatory reaction and cholesterosis or papillomas.

Once the indications are established, the earlier operation is performed the better.

Cholecystitis is a recurrent and progressive disease, and many surgical deaths are in reality medical deaths, from lack of surgical treatment until the adjacent organs have become hopelessly involved in the pathologic process. Statistics show that the mortality increases commensurately with the duration of the gallbladder symptoms. Operations upon the common duct, frequently necessitated by long standing cholecystitis, further increase the hazard.

Acute Cholecystitis. One of the strongest arguments in favor of early operation in chronic cholecystitis lies in the danger of an acute attack and possible perforation. In many cases of acute cholecystitis, the attacks are preceded by a long standing chronic cholecystitis and are induced by obstruction of the cystic duct by a stone and a superimposed infection. In others, they may be provoked by strangulation and edema of the ducts from some other cause.

It appears, however, that obstruction of the duct and infection are not the only factors in the production of acute cholecystitis. There is considerable experimental evidence that it may be of chemical origin. In a personal communication, W. D. Gatch calls attention to the fact that cholecystitis is rare in children, though infections are more common in children than in adults, and, further, that abdominal wounds rarely become infected following operations for acute cholecystitis. He likewise points out that the bile is sterile in the majority of cases of cholecystitis. In addition, it has been shown that bile salts introduced into the gallbladders of animals will precipitate an acute attack, as will pancreatic juice. Clinically, the condition produced is identical with that of acute spontaneous cholecystitis in man.

In this theory may be found an explanation for the fact that many cases of acute cholecystitis subside under treatment. It also explains those cases in which no stone is found in the duct at operation, the bile is sterile on culture, and infection is conspicuously lacking. From my own experi-

ence, the theory is entirely tenable, and I believe we should broaden our view to include a chemical etiology as well as an obstructive and infectious origin for the acute process.

As to the management of acute cholecystitis, in the first place the patient should be placed in the hospital at the earliest possible moment after the beginning of the attack. He can thus be better assured of receiving the care suited to his particular needs and can be promised a more favorable prognosis. In the second place, measures should be undertaken immediately to restore the depleted fluid balance in the tissues and otherwise prepare the patient for operation. Aside from this, the management must rest upon the findings in the individual case. Here, again, the difficulty is that the symptoms do not always reflect the true pathologic condition.

The clinical signs which are regarded as demanding immediate surgery are (1) sustained abdominal pain with rigidity, (2) a tender mass in the right upper quadrant, (3) an elevation of temperature and (4) a rising leukocyte count. Especially are sustained pain and a tender mass positive indications. Early in the attack, a mass may not be palpable, rigidity and tenderness may not be pronounced, and the temperature, pulse and leukocyte count may be essentially normal. In these cases, operation may be delayed while preparatory treatment is given. If the patient is in good condition, preparation over a period of twelve to twenty-four hours is sufficient. Often, however, a more extensive preparation is desirable, especially for patients who present a poor risk. Fortunately for these, the attack will usually subside, permitting operation at a more advantageous time. By keeping a close watch of the patient and the use of proper laboratory studies, one can generally determine what course the acute process is going to take within twenty-four to thirty-six hours after the onset. If, during this period, the symptoms do not begin to subside or if they become aggravated, operation is urgent.

One cannot discuss the subject of cholecystitis without referring to the bile ducts, because of the frequent association of duct disease with cholecystitis and the damaging effect of their obstruction upon liver function. Much of the current discussion is centered about the indications for opening the common duct. As is well known, obstructions necessitating choledochotomy may arise from stricture, carcinoma of the duct or pancreas, pancreatitis or other abnormalities, yet the vast majority are produced by a stone or stones.

In the hands of experienced surgeons, the practice of openly exploring the ducts is increasing. One reason for this is the fact more patients are being operated for cholelithiasis and fewer for non-calculous cholecystitis. Another is that the duct may contain stones even though the gallbladder contains none, and still another, the possibility of reformation of stones in the duct subsequent to cholecystectomy alone. Although these are excellent reasons, the fact remains that the duct should be opened only in the presence of ample indications. The mortality of the operation with either cholecystectomy or cholecystostomy is high. Admittedly, complications incident to advanced disease are responsible for most of the deaths, yet the procedure is often technically difficult and, in any case, adds to the surgical trauma and thus further taxes the patient's recuperative powers.

The findings commonly accepted as justifying choledochotomy may be enumerated as follows:

1. *Palpation of a Stone.* This is not always an easy matter. Moreover, one should take care not to mistake an enlarged gland for a stone in the duct.

2. *Abnormal Dilatation of the Duct.* Again, one should be sure that the dilatation is not functional, in compensation for loss of gallbladder function, or that it is not due to extrinsic mechanical obstruction. Or, the dilatation may be secondary to gallbladder disease and amenable to relief by cholecystectomy alone. If there is

thickening of the duct walls and evidence of infection within, however, choledochotomy is advisable; even though a stone should not be found, drainage should be instituted.

3. *Contracted Gallbladder.* When one encounters a gallbladder no larger than the thumb, one may be sure of a long standing infection. The gallbladder may not contain stones, yet is more than likely that they will be found in the duct.

4. *Multiple Small Stones in the Gallbladder with an Enlarged, Patent Cystic Duct.* Stones too small to be detected by the palpating hand will frequently pass from the gallbladder into the common duct. This may happen during mere manipulation of the gallbladder. In such cases, it is not only advisable to open the duct, but the cholecystectomy should be performed first in order that one may be sure the duct is entirely free of stones at the conclusion of the operation.

5. *Jaundice or a History of Jaundice, Especially if Associated with Chills and Fever or with Gallstone Colic.* Since these symptoms may also be produced by disturbances other than a stone, a thorough search should be made for an obstructing lesion before the duct is opened. It should be borne in mind, moreover, that duct stones may be present without jaundice.

6. *Flocculent Bile in the Duct.* When the presence of a stone seems doubtful, a small quantity of the contents of the common duct should be aspirated. If the bile is cloudy and flocculent, the duct should be explored and drained. Not infrequently, an obstructing stone will be found at the lower end.

To preclude a second choledochotomy, every possible means should be employed to clear the ducts at the initial operation. The exploration should include the hepatic as well as the common duct. The ampulla, also, should be thoroughly searched with scoops for any possible stones hidden in its recesses. In addition, the patency of the distal end of the duct should be demonstrated with a probe; not until this has

been done may one feel reasonably sure that the patient will have no further trouble. Should an obstruction be found at this point, the sphincter may be dilated almost to the size of the normal common duct without injury and with little fear of subsequent contraction, provided one uses bougies of graduated size. Finally, drainage should be instituted by means of a T-tube. The tube is brought out through a stab wound in the side and is not withdrawn until bile flows freely into the intestinal tract and there is no obstruction in the biliary tree, as determined by cholangiograms.

A vital influence in the success of operations for gallbladder and duct disease is the preoperative and postoperative treatment. Patients without evidence of long standing cholecystitis may not require any preparation other than the routine dietary restrictions and forced fluids. Those with advanced disease, however, should receive treatment directed especially toward conservation of liver and kidney function, as indicated by appropriate tests. The presence of jaundice increases the need for intensive preparatory measures. The prothrombin level in the blood should be determined and any hemorrhagic tendency counteracted, both before and after operation, by transfusions and the administration of vitamin K.

The icterus index affords an effective means of detecting and studying jaundice. Repeated tests will show whether the jaundice is deepening or subsiding. If possible, operation should be delayed so long as the index is rising or fluctuating, as the risk is less after the jaundice recedes to some extent.

When the common duct has been opened, liberal quantities of Decholin or some other cholagogue will be found advantageous in stimulating the flow of bile and promoting better drainage after operation. This treatment may be continued indefinitely.

Another important factor in the safety of the operation, and certainly the greatest aid to the surgeon is ample exposure of the

operative field. In the majority of cases, an upper right rectus incision, its middle over the region of the common duct, is suitable. In obese patients, however, the supraumbilical transverse incision is most advantageous, in that the tissues of these individuals are usually friable and this approach provides a safeguard against wound disruption and hernia.

When feasible, cholecystectomy is eminently preferable to drainage of the gallbladder. The mortality of the operation is low, recovery is rapid, and no further surgery is necessary. The risk of a primary cholecystectomy, moreover, is far less than that of a secondary procedure. If, however, the patient's condition is poor or if the inflammatory process is so extensive that identification of the ducts and vessels is impossible, it is better to insert a tube into the gallbladder and close the abdomen. One's chief concern should be the safety of the patient, and drainage may be a lifesaving measure, particularly in the presence of a perforation or following exploration of the ducts. The gallbladder may then be removed at a more advantageous time. Subsequent cholecystectomy is usually advisable, as a precaution against irreparable damage to the liver.

If the inflammatory process is severe, the technic of cholecystectomy may present some difficulties. Dissection should be carried out in a dry field, and one should be sufficiently familiar with the vessels and ducts to avoid their injury. The ducts and vessels are often abnormally situated, either naturally or because of edema or displacement by adhesions, and accessory ducts are commonly encountered. Incision or ligation of these anomalous or displaced structures may lead to serious consequences. No doubt, many so-called "liver deaths" are the result of damage to the blood vessels during removal of the gallbladder, and duct strictures incident to surgical trauma are found in a conspicuous number of operations upon the biliary tree.

The cystic duct should first be isolated, its relation to the common and hepatic

ducts determined, and the cystic duct and artery ligated before proceeding with removal of the gallbladder. In chronic or elective cases, dissection is begun at the cystic duct and continued from below upward, whereas if the condition is acute and the gallbladder greatly distended, dissection is begun at the fundus and carried downward. When jaundice is present, however, exploration is first carried out to determine the cause of the obstruction. Should an acute pancreatitis or a malignancy be found, it may be necessary to conserve the gallbladder. In these cases, the gallbladder is usually not materially diseased and may be successfully utilized for anastomosis to the intestinal tract.

The necessity for drainage of the gallbladder in the presence of infection is well understood. In other cases, whether to drain or close the abdomen tight following cholecystectomy depends more or less upon the finding of accessory bile ducts and whether or not the operative field can be made perfectly dry. As a rule, it is well to insert simple Penrose drains, bringing them out through a stab wound to the side of the incision. The patient experiences little inconvenience, and the drains are generally removed after four or five days.

A recent review of 803 surgical cases of cholecystitis revealed that 528, or 65.8 per cent, were of the chronic type; 132, or 16.4 per cent, were subacute; and 143, or 17.8 per cent, were acute. These findings and the mortality of each group are shown in the following table.

TABLE I
CLASSIFICATION OF 803 CASES OF CHOLECYSTITIS, WITH MORTALITY

	Cases		Mortality	
	No.	Per Cent	No.	Per Cent
Chronic.....	528	65.8	13	2.5
Subacute.....	132	16.4	6	4.5
Acute.....	143	17.8	14	10
Totals.....	803		33	4.1

Stones were found in 66 per cent of these fatal cases, and perforation had taken place in 40 per cent.

In the 803 cases, 682, or 85 per cent, of the operations were upon the gallbladder alone, while the ducts were opened and drained in 121, or 15 per cent. Ninety-seven of the choledochotomies were primary and twenty-four were secondary. (Table II.)

TABLE II
OPERATIONS IN 803 CASES OF BENIGN DISEASE OF THE
GALLBLADDER AND DUCTS

		Mortality	
		No.	Per Cent
Primary gallbladder operations without choledochotomy.....	653	17	2.6
Secondary gallbladder operations without choledochotomy.....	20	2	"
Primary gallbladder operations with choledochotomy.....	97	9	9.3
Secondary gallbladder operations with choledochotomy.....	24	5	20
Totals.....	803	33	4.1

The nineteen fatalities following operations upon the gallbladder alone constitute approximately 2.8 per cent of the 682 in this group, whereas the fourteen fatalities following the 121 combined gallbladder and duct operations constitute 11.6 per cent. Thus, the mortality was more than four times higher in the latter group. This is probably due to the fact that stones are usually associated with long standing disease in which other structures have become involved.

It is of some significance, also, that in 228 operations performed within the past two and one-half years, we have found stones in the gallbladder in 82 per cent, and in forty-four duct operations (20 per cent of 228) have found stones in the duct in forty, or 90 per cent. Although the number of our choledochotomies has not materially increased within recent years,

the recovery of duct stones has increased from sixty-six to 90 per cent. That stones were found in 90 per cent of only 20 per cent of choledochotomies indicates that the number in which the operation is performed is of far less importance than the use of sound judgment in observing the indications for the procedure.

CONCLUSIONS

Much of the success of gallbladder surgery depends upon the care with which patients are selected for operation. Aside from those who present both clinical and roentgenographic evidence of cholecystitis, there are a number of patients whose symptoms and roentgenographic findings are almost impossible of proper evaluation. Indeed, cholecystitis may mimic a wide variety of pathologic conditions. Probably the chief difficulty is encountered in the differential diagnosis of chronic non-calculous cholecystitis, as indicated by the fact that the larger number of poor surgical results are encountered in cases of this type. The desirability of exhaustive histories and meticulous studies cannot be too strongly emphasized. It is significant that the vast majority of patients who are completely relieved by operation are found to have gallbladder or duct stones, or both. Surgical opinion is almost universally in favor of removal of the gallbladder, when feasible, in the presence of stones.

Of material influence on the fate of these patients is early operation. When operation is delayed, the pathologic changes which take place throughout the biliary system not only further impair the patient's resistance, but necessitate more intensive preoperative and postoperative treatment, as well as more extensive surgery, and multiply the difficulties of the technical performance.

In acute cholecystitis, one is often confronted with the necessity for deciding between immediate and delayed operation. Usually, the attack will subside under appropriate treatment, permitting operation at a more advantageous time. One can

generally tell what course the acute process is going to take within twenty-four to thirty-six hours after the onset. A vital factor in the success of the treatment is the immediate hospitalization of the patient at the beginning of the attack.

Open drainage of the common duct is indicated when a stone is palpated in the duct, when the duct is abnormally dilated, when the gallbladder is contracted or contains multiple stones and the cystic duct is enlarged and patent, when the duct contains flocculent bile, and when the patient is jaundiced or gives a history of jaundice. By adherence to these criteria, stones will be recovered from the duct by choledochotomy in approximately 90 per cent of

cases. The indiscriminate opening of the duct is not justified and, by the inexperienced especially, should be undertaken with extreme caution.

In addition to these considerations, no operation should be performed upon the gallbladder or ducts without adequate preparation of the patient. When necessary, this should include measures to conserve liver and kidney function, to control hemorrhage and to counteract infection. At operation, ample exposure of the field, with care to identify the important structures, and postoperatively, measures to correct any physiologic and organic disturbances will have a favorable effect upon the outcome.



MEDICAL treatment sometimes relieves symptoms, but never removes stones from the gall bladder. Unless there is some definite contraindication to operation the correct treatment for stones in the gall bladder is cholecystectomy.

From "A Short Practice of Surgery" by Hamilton Bailey and R. J. McNeill Love (H. K. Lewis & Co. Ltd.).

ACUTE PANCREATITIS*

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THE great diversity of opinion on the classification, etiology, symptomatology and treatment of acute pancreatitis attests to our limited knowledge of this disease. Although the condition is comparatively rare, it frequently presents a major surgical problem, carrying with it a high mortality. Careful analysis of clinical experiences and statistical studies of autopsy findings have given us added information of acute pancreatitis. In an effort to substantiate and increase this information, we have carefully analyzed the histories and pathologic findings of proven cases of acute pancreatitis occurring in the Veterans Administration Hospital at Hines, Illinois, during the past twelve years. The diagnosis was established in five patients at the operating table; three recovered and two died and had the diagnosis confirmed at necropsy. Fifteen additional patients were not operated upon but had the diagnosis established at autopsy. As there were 4,810 necropsies performed during this time, the seventeen deaths due to acute pancreatitis give an incidence of $\frac{3}{10}$ per cent. Weiner and Tennant analyzed 4,000 autopsies performed at the New Haven Hospital and found thirty-eight cases of acute pancreatitis, an incidence approximately twice that of our series.

To avoid inclusion of information from possible diagnostic errors, we have analyzed only those cases in which the existence of acute pancreatitis was confirmed at operation or autopsy. Patients with a clinical diagnosis of acute pancreatitis who recovered without surgical intervention have not been included in this study. Pa-

tients in whom a questionable diagnosis of edematous pancreatitis was made at operation but in whom fat necrosis was not found have been eliminated from this series.

CLASSIFICATION

The classification of degrees of inflammation of the pancreas has varied markedly with different authors. Early classifications of acute, subacute and chronic inflammation were given. Fitz, in 1889, divided acute pancreatitis into hemorrhagic, gangrenous and suppurative. He described the hemorrhagic type as "peracute," and the gangrenous as acute, believing that it generally resulted from hemorrhagic pancreatitis. In more recent years authors have quite generally agreed on a classification of acute edematous pancreatitis which is a fairly mild form, and on a more fulminating and severe variety referred to as acute hemorrhagic pancreatitis or acute pancreatic necrosis. Boyd points out that in this latter form there may be little or no hemorrhage, and the lesion is more necrotic than inflammatory. Coffey believes the difference between these two types is the lack of intraglandular activation of trypsinogen in the edematous type. Cole suggests that the edematous type is the result of obstruction of the ducts, whereas the necrotic type is the result of tryptic digestion within the gland. In our series of seventeen autopsy reports, 65 per cent were found to have the acute hemorrhagic form of pancreatitis. The remaining 35 per cent were diagnosed as acute suppurative pancreatitis. Fat necrosis and bloody fluid within

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FIG. 1. Fat necrosis and tissue destruction of omentum removed at necropsy from a patient who died of acute pancreatitis.

the peritoneal cavity were present in all cases. Six of the patients had abscesses of capacities varying from 10 to 500 cc.

ETIOLOGY

The frequent association of biliary tract disease with acute pancreatitis strongly suggests a close correlation between these diseases. Morton reports that 62 per cent of a series of ninety-seven cases had antecedent biliary tract disease. Lampson found that 55 per cent of twenty-nine patients with acute pancreatitis had gallstones. de Takats and MacKenzie noted an involvement of the biliary tract in 81 per cent of twenty-two cases, and Connell found gallstones in twenty-four of twenty-six patients with acute pancreatitis with fat necrosis. Carter and Hotz reported stones in the common duct in seventy-eight of their series of acute pancreatitis, while Cole found cholecystic disease in all eight of his patients seven with stones in the gallbladder and five with stones in the common duct as well. In our series of twenty cases, 55 per cent were found to have gallbladder disease. Cholelithiasis was found in eighteen and two of these also had

stones in the common duct. Multiple liver abscesses also were found in two patients. In contrast to these reports, Weiner and Tennant found a co-existence of biliary tract disease in only 16 per cent of their necropsy findings of acute pancreatitis.

A number of theories have been advanced as to the mechanism by which biliary tract disease initiates acute pancreatitis. The transmission of bile into the pancreatic ducts has been advanced as an etiologic factor. Having found a stone impacted in the ampulla of Vater which permitted bile to be short circuited into the pancreatic duct, Opie advanced the theory that blockage of the ampulla, converting the common duct and the duct of Wirsung into a single channel, permitted bile to enter the pancreas and was the etiologic factor of pancreatitis. Archibald believed this same mechanism could result from spasm of the sphincter of Oddi. Robins believes that in the necrotic type, bile initiates the original necrosis. Several known facts argue against the theory that bile entering the pancreatic ducts produces acute pancreatitis. McCaughan found that this disease could be produced in dogs by



FIG. 2. A, the external appearance of the pancreas showing extensive necrosis.

the injection of bile, gastric juice or virulent bacteria only if sufficient pressure is used to rupture the pancreatic ducts. The necessary pressure is higher than that known to occur in the choledochus under any conditions. Anatomic studies have shown that only rarely is it possible for bile to enter the pancreatic ducts from the choledochus in man. Necropsy studies on patients with acute pancreatitis have generally proven that it was impossible for bile to enter the pancreatic ducts from the common duct. In our series of autopsies the relationship of the common bile duct to the pancreatic duct was accurately described in four cases. In one of these there was a common ampulla. In another, the openings were separate but adjacent at the papilla of Vater. In the third, the pancreatic duct inserted into the common duct. In the fourth, the pancreatic duct entered the duodenum 2 cm. lateral and proximal to the papilla of Vater. The work of Wolfer, who found that the secretory pressure of

the pancreas is greater than that of the liver, further argues against the bile theory in the etiology of acute pancreatitis.

The transmission of bacteria from a diseased biliary tract to the pancreas has been considered as an etiologic factor in acute pancreatitis. Theories have been advanced that this infection could be transmitted by the blood stream, by the lymphatics, by direct extension or by transmission through the ducts. Robins, Dragstedt et al. agree that although frequently organisms can be cultured from the normal pancreas, the overwhelming toxicity in acute pancreatic necrosis is due to the results of protein decomposition rather than to toxins produced by bacteria.

Obstruction of the pancreatic duct may be an important etiologic factor in the production of pancreatitis. The frequency of the association of biliary tract disease with inflammation of the pancreas strongly suggests this. Stones in the common duct may cause pressure on the duct of Wirsung.



FIG. 2. B, the pancreas sections showing extensive hemorrhage and necrosis.

Swelling and edema of the extrahepatic biliary tract and its surrounding structures may do likewise. Rich has suggested that metaplasia of intraductal cells within the pancreas also might produce obstruction. In our series of seventeen necropsies for acute pancreatitis, definite obstruction of the pancreatic duct was found in five cases. In two, the ducts were blocked by fibrous tissue; in one, by a duodenal ulcer adjacent to the duct; in one, by an adenocarcinoma of the ampulla of Vater; and in the fifth, by a suture which had been placed about the pancreatic duct during the course of a gastrectomy performed for carcinoma of the stomach four days prior to the onset of symptoms of pancreatitis. In another case, acute pancreatitis and death occurred five days after a partial gastrectomy for a penetrating duodenal ulcer which had been dissected from the head of the pancreas.

Certain dietary habits are believed to be factors in the development of acute pancreatitis. Many attacks appear to follow the ingestion of large meals. Weiner and Tennant made the interesting observation that in fifty-one deaths following the excessive ingestion of alcoholic beverages,

acute pancreatitis was found in twenty-five cases. Rhodes mentions external trauma as the direct etiological agent in five of his series of thirty-five patients with acute pancreatitis.

SYMPTOMATOLOGY

The symptoms of acute edematous pancreatitis are similar to those of acute hemorrhagic pancreatitis but of a milder degree. Pain is almost universally present, varying in degree with the severity of the pancreatic involvement. Its onset was sudden in 60 per cent of our cases and it occurred in the epigastrium in 70 per cent. It was diffuse in two cases, predominantly in the right upper quadrant in three, in the lower abdomen in two, and in the right lower quadrant in two patients. It was more pronounced on the left in only one patient. All patients with pain in the right upper quadrant had associated gall-bladder disease. Although mention is often made of radiation of pain to the back, this occurred in only one of our patients. In approximately half of our patients the pain was sharp and severe, and in the remainder it was described as dull. Nausea and vomit-

ing universally was present. Three patients manifested chills and all subsequently were found to have pancreatic abscesses. Prostration or shock was found in over half of this series. None of the patients who survived surgery were in shock before operation. The admission temperature of these patients varied from 97° to 104°F., averaging 101°F. It is of interest to note that the preoperative temperature was normal in all patients who survived surgery. A history of previous attacks similar in character but milder in severity was given by four of these patients. Although eleven of the twenty patients were found to have disease of the gallbladder, only two gave a history of previous biliary attacks.

Examination revealed tenderness in all but four patients and these were either under the influence of opiates at the time of admission to the hospital or were moribund. The location of the tenderness corresponded roughly to the location of the pain. It was chiefly in the epigastrium in 50 per cent and chiefly in the right upper quadrant in another 50 per cent. This latter group all proved to have concomitant gallbladder disease. Left upper quadrant tenderness was marked in only one case. Muscle spasm corresponding to the area of tenderness was noted in 60 per cent of the patients. It is of interest to note that distention was mentioned as a prominent physical finding in all twenty of these patients. Audible peristalsis was more frequently absent than present. Jaundice has been frequently mentioned as a symptom of acute pancreatitis but was infrequent in our series. Many of the more serious patients manifested symptoms of shock consisting of a rapid pulse and low blood pressure with the characteristic restlessness and cold, clammy skin. Leucocytosis was invariably present in our series; the leucocyte count ranging from 11,000 to 45,000 and averaging over 20,000. All patients who recovered had a leucocyte count below 20,000. Glycosuria is an infrequent finding, being noted in six of thirty-seven patients by Elman, and in four of thirty

cases by deTakats and MacKenzie. Metheny reports the presence of albuminuria in all of his thirty-two cases. Others have corroborated this observation and believe that the absence of albuminuria should make one doubt the existence of acute pancreatitis.

DIAGNOSIS

Before the use of serum amylase determinations as a diagnostic aid, the incidence of a correct diagnosis of pancreatitis prior to operation or necropsy was infrequent. It is believed that the use of this test will greatly improve diagnostic accuracy. In a series of sixty-four cases analyzed by McWhorter, a correct diagnosis was made in only 11 per cent. In a series of thirty-five cases analyzed by Lewison, a similar percentage of accuracy in diagnosis was made with pancreatitis being considered as an additional possibility in 6 per cent of the remaining patients. Elman collected a group of thirty-seven patients having acute edematous pancreatitis in which the correct preoperative diagnosis was not made in a single instance. He also made the interesting observation that twenty-four patients of this series had histories of previous attacks. deTakats and MacKenzie likewise reported that in their thirty cases a correct diagnosis had not been made in a single instance.

The determination of serum amylase is believed to be a valuable aid in the diagnosis of acute pancreatitis and most observers agree that the differentiation between edematous and necrotic pancreatitis often can be made by its use. Lewison emphasizes the importance of the amylase test, especially if the patient is to be treated conservatively. He found that the serum amylase values are constant in the human being and are not influenced by age, sex, diet, vitamin deficiency or starvation. He also observed that diseases of the liver and biliary tract depress the serum amylase whereas acute pancreatitis elevates it. Metheny et al. concluded from their study of thirty-two cases that in the necrotic

type of pancreatitis the amylase level returns to normal or below in two to three days but in the edematous type it requires an average of eighteen days for a normal value to be re-established. Morton agrees with these principles and believes that the serum amylase level is of the greatest importance in deciding whether or not to operate. Elman disagrees with these concepts and although he admits that the serum amylase tests will indicate a serious pathological condition in the pancreas, he does not believe that the two types of pancreatitis can be differentiated in this manner. Clasen et al. explain the fall of serum amylase to normal or below after the initial rise by postulating that it may be due to the "walling off" and fibrosis of the involved areas of the pancreas.

The preceding paragraphs enumerate the symptoms and findings which should suggest the diagnosis of acute pancreatitis. The patient usually gives a history of an acute onset of abdominal pain which may vary considerably in intensity. This pain is most frequent in the epigastrium and the right upper quadrant and rarely radiates to the back. There is associated tenderness and often rigidity in the area of pain. Nausea and vomiting invariably are present. If the disease is severe, the patient will present a picture of shock with a low blood pressure, rapid pulse, apprehension and a cold, clammy skin. There likely will be a history of previous milder attacks and often a history suggestive of biliary tract disease. Laboratory examinations will reveal a leucocytosis and probably an albuminuria. A serum amylase determination will show a definite elevation of the serum amylase if the test is made within two or three days of the onset of the symptoms.

DIFFERENTIAL DIAGNOSIS

With the present tendency toward conservative treatment of acute pancreatitis, it is most important to reach a correct diagnosis. Acute cholecystitis may be confused with acute pancreatitis and may exist in conjunction with the latter disease.

Here the serum amylase test is of considerable value for if acute pancreatitis does not exist the serum amylase level should not be elevated. The most important disease to differentiate from acute pancreatitis is a perforated peptic ulcer. As this condition demands immediate surgery whereas pancreatitis is treated conservatively, every effort should be made to differentiate between these two abdominal emergencies. They often will present very similar pictures, especially if the pancreatitis is of the hemorrhagic type. There are certain diagnostic criteria which are of value in making a differential diagnosis. If a perforated peptic ulcer drains freely into the peritoneal cavity, it will produce a spreading peritonitis with a diffusion of pain gradually producing a generalized board-like rigidity of the abdomen. An x-ray plate taken with the patient in a vertical position usually will show air under the diaphragm. The serum amylase will not be elevated. Although many authors consider perforated peptic ulcers as silent ulcers, a carefully taken history frequently will elicit pre-existing ulcer symptoms.

Other acute abdominal conditions occasionally may simulate acute pancreatitis or be confused with it. An acutely inflamed or gangrenous appendix lying high behind the ascending colon may present a difficult diagnostic problem. An acute diverticulitis, especially with perforation, also may produce symptoms difficult to differentiate from those of acute pancreatitis.

TREATMENT

Surgical intervention which formerly was advocated for all cases of suspected acute pancreatitis has produced such poor results that more conservative treatment is generally replacing it. This is true especially of the acute edematous type of pancreatitis in which nonoperative therapy has been followed by a far greater incidence of recovery than any form of surgical intervention. The primary indication for early operation in acute pancreatitis is a questionable diagnosis. If a perforated viscus is

suspected and the patient is not in shock, an immediate operation may be indicated. Suspicion of an acute cholecystitis does not justify early operation because the danger of perforation of an acute gallbladder is much less than the increased mortality resulting from early surgery in a cholecystic disease. We believe this applies even where there is elevation of serum amylase levels.

We would like to outline the treatment of acute abdominal catastrophes which could be produced by acute pancreatitis. If a patient is admitted to the hospital in shock or in an extremely critical condition, immediate surgery usually will prove fatal. He should be put at rest and his pain relieved by morphine. His stomach should be kept at rest by avoiding all oral feedings and by continuous gastric suction. Whole blood and glucose solutions should be given intravenously to combat shock and to maintain fluid balance. Oxygen should be administered if indicated. Careful observation and x-ray studies should be utilized to determine the possible existence of a ruptured viscus. If this is suspected and the patient's condition permits, early surgical intervention is mandatory. If a ruptured ulcer is found at operation, it must be closed and adequately protected. However, if acute pancreatitis is found, any conditions bearing upon its etiology may have to be treated. If the biliary tract is diseased it should be decompressed. In most cases the acute nature of the disease and the critical condition of the patient will justify only the minimal amount of surgery to accomplish the release of biliary pressure. Cholecystostomy usually is the operation of choice. In this early stage, abscess formation in the region of the pancreas is rare and attempted drainage of an edematous or hemorrhagic pancreas is both impossible and useless.

If immediate surgery is not decided upon, intensive conservative therapy should be continued. Absolute mental and physical rest must be maintained as well as freedom from pain. Parenteral feeding

of glucose, saline, proteins and blood should be continued and guided by careful laboratory studies. These should include estimations of blood chlorides, total proteins, careful and repeated checks on the red and white blood cell counts and an accurate check of fluid intake and output. Serum amylase levels should be followed closely to determine the presence of pancreatic involvement. Blood sugar levels will serve as a guide to the administration of insulin.

Subsequent care will depend largely upon the response of the patient. If clinical studies and serum amylase determinations suggest an acute pancreatitis secondary to a biliary tract disease, operative intervention should be urged when the patient's symptoms have subsided. It is well to wait for several weeks when the patient will be in better condition to withstand surgery so that the gallbladder may be removed and the common duct drained if the operative findings justify these procedures. A cholecystostomy almost invariably must be followed by subsequent cholecystectomy and it is well to delay surgery until adequate biliary treatment can be instituted at the first operation. If symptoms of a pancreatic abscess develop, this should be subsequently drained. It will be indicated by persistence of fever, of leucocytosis and frequently of a tender mid-abdominal mass. Such symptoms should suggest this even though the serum amylase level has returned to normal or below.

SUMMARY

The difficulty in differentiating between acute pancreatitis and other abdominal catastrophes is proven by the high incidence of diagnostic errors. It is most important to recognize perforations of peptic ulcers as immediate surgery is mandatory to good results. On the other hand, conservative treatment of acute pancreatitis gives a far lower mortality than that following early operative intervention. The determination of serum amylase levels has been a valuable addition to our diagnostic armamentarium as these rise sharply in

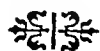
the early stages of acute pancreatitis but are not increased in other acute abdominal conditions.

The usual symptoms of acute pancreatitis are as follows: The history of acute abdominal pain varying in intensity and being most frequently located in the epigastrium and the right upper quadrant; tenderness and often rigidity in the area of the pain; nausea and vomiting invariably existing with shock accompanying severe attacks. There is often a history of previous milder attacks or of biliary colic. Jaundice is not infrequent. The leucocyte count is markedly elevated. Glycosuria and albuminuria frequently are found.

Conservative therapy consists of relief of pain, rest in bed, continuous gastric rest and suction, adequate parenteral feedings to maintain blood chemistry and fluid balance, blood transfusions to overcome shock and careful observation. When the acute symptoms have subsided and the patient's condition has improved, biliary tract surgery should be contemplated if evidences of disease are found. Late drainage of pancreatic abscesses may be indicated.

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TRAUMATIC LESIONS OF THE ABDOMEN WITH RUPTURED VISCERA

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ABDOMINAL injuries are usually serious. They may be divided roughly into penetrating and non-penetrating wounds, and intra-abdominal trauma without visible wounds of the abdominal wall. All penetrating and non-penetrating wounds require surgical exploration and débridement. All penetrating wounds also require careful systematic inspection of all viscera and the performance of the least surgical procedure compatible with saving life. Patients with intra-abdominal trauma without visible wounds of the abdominal wall often require a period of observation for diagnosis and may or may not require operation.

Successful treatment in the surgery of trauma depends in no small measure on the speed and efficiency with which the casualty is admitted to the hospital. If the mortality rate of injuries to the abdomen is to be maintained at a minimum, it is of prime importance that the time lag or the period between the incidence of the trauma and the consummation of definitive treatment be reduced to as short a time as possible. This means that the speed of transport of the casualty to a hospital or station where careful examination can be made and treatment be directed is of utmost importance. There is little that the layman can do at the site of injury except call for an ambulance with dispatch and inform the driver of getting the patient to the hospital as soon as possible.

The mechanism of trauma to the abdomen may be of many different types. The most common causes are as follows: (1) Direct blow to the abdomen by some blunt object such as a piece of wood or a tool that the workman is using; (2) a fall from

a height of a few feet or more, the impact of landing producing the injury; (3) injuries resulting from stab or gunshot wounds, and (4) squeezing injuries, such as are caused by being caught between moving objects.

ANATOMY

In considering trauma to the abdomen the surgeon must keep in mind the anatomical structures which constitute the abdominal region. This region consists of the abdominal wall which is supported by the ribs and the spine and is anchored to a bony frame work, the pelvis, at the lower portion. The abdomen contains two types of organs, the solid ones, such as the liver, spleen, kidneys and pancreas, and the hollow ones, the stomach, the intestines, the gallbladder and the urinary bladder. The supports of the abdominal organs are more or less elastic and contain blood vessels which may be so injured that fatal hemorrhage follows. The solid organs have a more or less constant size and shape that undergo but little variation with changes in the physiologic status of the individual. The spleen becomes engorged and full after the ingestion of a meal, while the other solid organs vary but little, if any.

The hollow organs vary their size and shape considerably during the normal daily activities of the organism. After a meal the stomach will increase greatly in size as will the small bowel when food enters its lumen. The urinary bladder will vary greatly in size and become overstretched under tension. When an organ is distended it is far more liable to injury than when it is empty; consequently, abdominal injuries are more likely to produce severe damage

to the hollow viscera when they are sustained soon after the ingestion of food.

Shock and hemorrhage commonly accompany all three types of abdominal trauma and may be adequately treated by various measures. Hemorrhage is synonymous with shock in intra-abdominal trauma, and therefore, operation to control it should not be delayed.

When visceral injury is present the following signs* may be noted:

"1. Marked muscle resistance is one of the most reliable signs of visceral injury. It is usually quite marked, and if progressive is almost pathognomonic.

"2. Tenderness is often exquisite. In the early stages, it is localized in the region of injury; later it becomes more diffuse due to peritoneal irritation by infection or blood.

"3. Shock of variable degree; pallor, cold extremities, subnormal temperature, blood pressure and rapid pulse are almost invariably present. A progressive increase of pulse rate and fall in blood pressure with or without thirst, pallor and restlessness indicates continued hemorrhage. The so-called delayed or secondary shock is usually due to hemorrhage and should be considered.

"4. Dullness in the flanks, shifting on changing position indicates fluid, usually blood, but may be gastrointestinal content or urine and peritoneal effusion.

"5. Obliteration of liver dullness indicates pneumoperitoneum (free gas) and is due to perforation of the gastrointestinal tract. After several hours it may be due to gas elaborated by the bacteria causing the peritonitis.

"6. Blood in the vomitus or stool suggests gastrointestinal injury; blood in the urine indicates injury to the urinary tract.

"7. Peristalsis will usually be absent when the abdomen is auscultated. In the presence of intraperitoneal inflammation, there is reflex atony of the bowel in the effort to avoid movement and dissemination of the irritating material until localization can be completed by adherence

about the area. The presence of food or laxatives, however, tends to produce peristalsis in spite of the normal quieting influence.

"8. The hemoglobin and red count usually do not show definite decrease in the first hour or two even though there is considerable hemorrhage because all parts of the blood are lost in equal proportions. However, the blood loss is rapidly rebuilt in total volume by absorption of fluid from the tissues, the gastrointestinal tract and from the intravenous administration of fluid at such times. This will produce a dilution of the remaining blood and the disproportion will show in decreased hemoglobin and red blood cells when a count is repeated in 2 or 3 hours. On the contrary, the white blood cells usually show an early marked increase both in the total count, in the percentage of polymorphonuclears and in proportion of immature cells. Hemorrhage may produce an excessive response of this sort to 30,000 or even above."

MANAGEMENT

When a patient has received an injury to the trunk, as often as not, there is little to guide the surgeon in the matter of external bruising. The problem confronting the surgeon is to decide and decide as quickly as possible whether or not the patient has sustained an intraperitoneal or intra-abdominal lesion. This is often a difficult matter, particularly since the patient with trauma to the abdomen is suffering from shock when first seen.

The prelude to the examination of an injury to the abdomen is to inquire of the patient, if he is able to comprehend and respond, as to the mechanism of the injury. Has he vomited since the accident? Did the vomitus contain blood; if so, it is more definite evidence of gastric injury. Has the patient passed urine since the accident, and was there any blood in the urine? Has there been any passage of blood from the rectum? Of what does the patient complain? Ask the patient to point with one finger where the pain is most acute and mark this location. Often the patient

* The Cyclopaedia of Medicine, Surgery and Specialties; Volume 1—page 25, W. Emory Burnett, M.D.

may accurately locate the site of a perforation. Pain is important if localized and persistent.

Note and record the patient's temperature, the rate of the pulse, its quality and volume, respirations, and the blood pressure. Check and record the pulse, its quality, and blood pressure every fifteen minutes. A blood count including red cell count and white cell count, and estimation of hemoglobin should be made immediately, recorded and repeated every hour.

If the patient is able to urinate, a urinalysis should be made particularly checking for the presence of blood. If the patient is unable to urinate, catheterization should be resorted to with the caution not to use force and add more trauma if a ruptured urethra is suspected.

Roentgenograms showing the entire abdomen, including the pelvis and lower chest should be taken. In some cases it is well to take lateral views to look for areas of free gas in the abdomen.

On physical examination careful inspection should be made to notice any external evidence of injury such as swelling, abrasions, areas of redness or discoloration of bruising to determine if any fractures are present about the pelvis, spine or ribs; by palpation of the abdomen to determine if there are any local points of tenderness or muscular resistance. Areas of dullness or tympany should be noted and such areas marked with a pencil for checking at subsequent examinations.

The shock, when present, should be promptly treated. Body heat should be conserved; the foot of the bed may be elevated 12 to 15 inches; 500 cc. to 1,000 cc. of plasma when available should be given intravenously; and the judicious use of 500 to 1000 cc. of 5 per cent glucose in normal saline considered.

If after the above the extent of intra-abdominal injury is not evident, the patient should be put to bed for observation. Repeated examinations should be made at least every thirty minutes until a positive diagnosis or decision is reached. Do not give anything by mouth. While we appre-

ciate the value of the relief of pain in combating shock, it is advisable to avoid sedative drugs, such as morphine, during the observation period as they tend to mask important symptoms.

The surgeon should make a positive diagnosis of intra-abdominal injury within less than six hours from the time of the accident, preferably within two to four hours if possible. A patient operated on within six hours, as a rule, has a good chance for recovery; after six hours the chance of recovery greatly diminishes.

In perforating wounds of the abdomen, such as gunshot or stab wounds, it is apparent that the abdominal wall has been pierced so that immediate operation to repair the defects should be performed. This type of injury is usually evident and need cause no delay in making a diagnosis and deciding the treatment.

In selecting an anesthetic, preference is given to nitrous oxide, cyclopropane or ethylene preceded by one or two injections of morphine-scopolamine, depending on the available time before operation is begun. We have found the use of curare (intocostrin) intravenously just preceding and during the inhalation anesthesia of material aid in providing desirable relaxation.

Squeezing injuries to the abdomen may result in injury to the hollow organs, such as the gastrointestinal tract or urinary bladder; may rupture blood vessels causing dangerous hemorrhage, and in addition may produce fractures or lacerations of the solid structures such as the liver, spleen, kidneys or pancreas.

Injuries to the liver and spleen may be treated conservatively if one can be reasonably sure that the patient is not developing a serious hemorrhage. With evidence of internal hemorrhage it is essential to open the abdomen and control the source of the bleeding. In addition to the usual signs of hemorrhage one should look for referred pain to the left shoulder (Kehr's sign) which is frequently present when blood is in contact with the undersurface of the diaphragm. Another valuable maneuver is the application of Saegesser's sign, apply-

ing deep finger-point pressure between the sternomastoid and the scalenus medius on the left side. If positive in the case of a ruptured spleen, even in cases of intracapsular hemorrhage the pressure elicits violent pain.

A ruptured spleen may be safely removed with no subsequent ill after-effects. We have never tried to suture the spleen but have removed it when necessary.

Injuries to the liver can best be managed by resorting to suturing or using a simple gauze pack or using omentum. The use of fibrin foam and thrombin or gelatine sponge have also been recommended to control bleeding effectively from small lacerations of the liver, spleen and kidneys.

Lacerations of the stomach and intestine should be closed; in the case of the intestines the openings are closed in such a manner that the completed suture line is transverse, thus increasing the diameter of the lumen. If the intestine is badly damaged or deprived of blood supply by mesenteric damage, resection and end-to-side or side-to-side anastomosis may be done. In the case of a rupture of a hollow viscus with peritoneal contamination with spillage of gastrointestinal content, the foreign material is removed by suction followed by a liberal use of sulfathiazole and suitable drainage.

In the postoperative care one may stress the use of penicillin intramuscularly or it may be added to whatever fluids are administered intravenously to maintain a proper fluid balance. Mention is also made of the use of the Wangenstein constant suction apparatus and the Miller-Abbott tube to relieve and combat gastric and intestinal distention.

Injuries to the kidneys are fairly common complications of abdominal trauma and are best treated in a conservative way. Hematuria, the most prominent symptom in renal injuries, is usually present from the onset and may persist for one to two weeks. Associated with the hematuria is pain in the back which increases in severity so as to require sedatives. There is also a moderate degree of shock present in most

cases. A careful check on the blood pressure at intervals of one to two hours, as a rule, will give an indication as to the extent and severity of the injury. It is also important to keep a close observation on the blood pressure. If the patient's general condition goes along in a satisfactory manner, conservative and supportive management is indicated, although the use of drainage in the loin may be necessary later. If the patient's condition appears critical, it may be necessary to explore the kidney area so as to control hemorrhage and institute drainage. In some cases it is necessary to do a prompt nephrectomy or resort to a pack.

A rupture of the bladder can be anticipated in injuries about the pelvis, especially if fracture is present. The urine should be examined for presence of blood. Additional investigation should be made by injecting a known amount of solution into the bladder and by being able to withdraw a like amount. If evidence of rupture is found, prompt repair is necessary.

SUMMARY

The following points should be observed:

1. Prompt transportation of the injured to a hospital or station where definite treatment may be executed.
2. Careful history as to mechanism and severity of injury.
3. Examination of the injured with making of records and prompt laboratory procedures. Repeated examinations at frequent intervals until a surgical opinion has been reached.
4. Prompt use of measures to combat shock and control hemorrhage; operation when indicated within the first six hours if possible. It is better to operate in cases which present indefinite and obscure findings with a possibility of serious abdominal injury, than to consider conservative observation too long.
5. Chemotherapy with the use of sulfa drugs and penicillin to combat infection.
6. Judicious use of methods to maintain a proper fluid balance and to combat distention postoperatively.

PROGRESS IN THE TREATMENT OF ACUTE APPENDICITIS*

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IN the past two decades four major contributions to the field of surgery were applied to the treatment of acute appendicitis. These were: (1) intragastric suction, (2) intravenous fluids, (3) whole blood and plasma transfusions, and (4) chemo and antibiotic therapy. The fact that these

STATISTICAL SURVEY

This review includes an analysis of 5,543 patients with acute appendicitis treated at the Cook County Hospital. The care of these patients is largely entrusted to surgical interns and residents. The patients come from an indigent population who

TABLE I.
MORTALITY RATE OF 5,543 CASES OF ACUTE APPENDICITIS.

Year	Acute Appendicitis						Total Number Cases	Overall Mortality Rate, Per Cent
	Cases Without Perforation	Mortality Rate, Per Cent	Cases With Perforation	Mortality Rate, Per Cent	Cases With Abscess	Mortality Rate, Per Cent		
1928 to 1932	1,857	1.1	519	26.4	481	12.2	2,857	7.6
1937 and 1938	1,585	0.39	262	23.3	240	6.8	2,094	3.9
1944 and 1945	281	0.78	136	13.9	75	5.3	592	4.3

improvements came consecutively rather than concurrently permits us to evaluate their effects upon the treatment of appendicitis, together with other principles less influenced by time. For this purpose we have selected three representative periods in the history of the Cook County Hospital: (1) patients treated between 1928 and 1932 to whom intravenous fluids and intragastric suction were available; (2) patients treated during 1937 and 1938 when the use of blood was made available by the establishment of a blood bank; and (3) patients treated during 1944 and 1945 who were given sulfonamide and/or penicillin in addition to other adjuvant therapy. The first two groups of patients were first reported by one of us (K. A. M.) in an earlier report¹ but they will be utilized as a basis of comparison for more recent methods of treatment.

resort to self-medication and treatment for many hours or days before reporting to a hospital. The results, therefore, can never equal those reported by private institutions. Furthermore, war-time prosperity has caused a marked decline in the number of patients.

MORTALITY RATE. In Table I this material is divided according to a classification which we consider important, both from the point of treatment and prognosis: acute appendicitis *without* perforation, acute appendicitis *with* perforation, and acute appendicitis with abscess. Between 1928 and 1932, 1,857 patients with acute appendicitis without perforation were treated by appendectomy with a mortality of 1.1, per cent. During 1937 and 1938, 1,585 such patients were treated with a mortality rate of 0.39 per cent. During 1944 and 1945, the number of such pa-

* From the Hektoen Institute for Medical Research of the Cook County Hospital, the Department of Surgery of the Cook County Hospital and the Cook County Graduate School of Medicine, and the Department of Surgery, Northwestern University Medical School.

tients was 281 and the mortality rate 0.78 per cent.

During the period from 1928 to 1932, 519 patients with acute appendicitis with perforation were admitted and the mortality rate in this group averaged 26.4 per cent. During 1937 and 1938, 262 such cases were admitted and the mortality rate was 23.3 per cent. In 1944 and 1945, 136 patients with acute perforative appendicitis were admitted with a mortality rate of 13.9 per cent.

In 481 patients with acute appendiceal abscess during the years 1938 and 1932, the mortality rate was 12.2 per cent. In 249 such patients admitted in 1937 and 1938, the mortality rate was 6.8 per cent. For seventy-five such patients admitted during 1944 and 1945, the mortality rate was 5.3 per cent.

Comparing the over-all mortality rate for all three types of cases treated during each period, we found that in 2,857 patients treated during the 1928 and 1932 period, the mortality rate was 7.6 per cent; for 2,094 patients treated between 1937 and 1938, the mortality rate was 3.9 per cent; of 592 patients of all three types of appendicitis treated during 1944 and 1945, the mortality rate was 4.3 per cent. The latter figure requires interpretation because the census of patients with acute non-perforative appendicitis showed a far greater decrease than did the other two more serious types of appendicitis.

Influence of Surgical Intervention in Patients with an Acute Appendiceal Abscess. Table II represents a more detailed analysis of cases of acute appendiceal abscess treated with and without operation. There were 346 such patients treated by removal of the appendix and/or drainage of the abscess during the two periods, 1928–1932 and 1937–1938, with a resultant mortality rate of 18 per cent. During the same periods 284 patients were treated conservatively (Ochsner regimen) and the mortality rate was 4.2 per cent.

During the years 1944–1945, twelve patients with an acute appendiceal abscess

were operated upon with a mortality rate of 8.5 per cent; in sixty-three patients who were not operated upon the mortality rate was 3.1 per cent.

TABLE II
INFLUENCE OF SURGERY UPON MORTALITY RATE OF
PATIENTS WITH AN ACUTE APPENDICEAL ABSCESS

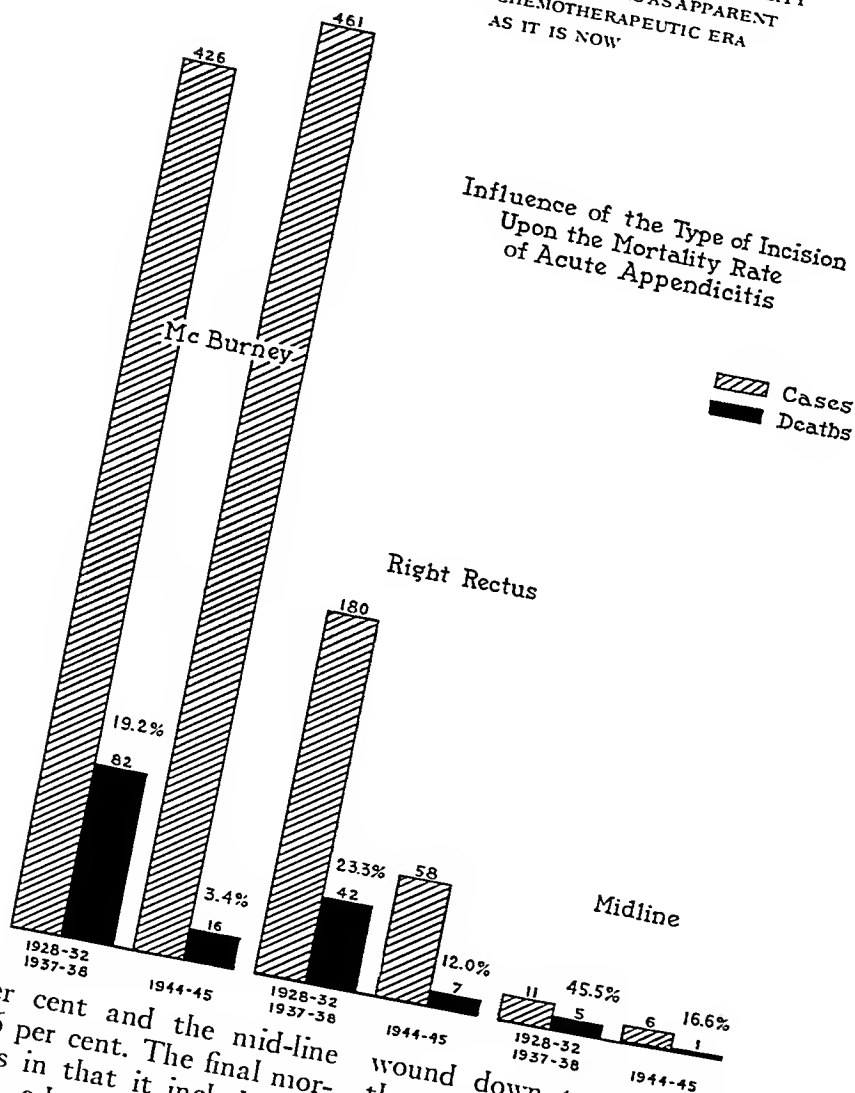
Year	Operated		Non-operated	
	Number of Cases	Mortality Per Cent	Number of Cases	Mortality Per Cent
1928–32 and 1937–38	346	18	284	4.2
1944–45	12	8.5	63	3.1

Influence of Incision upon Mortality Rate. The incisions employed for appendectomy in these patients were usually of three general types with slight modifications: McBurney, right rectus, and mid-line or paramedian. The latter incision was used when the diagnosis was in considerable doubt. For this particular analysis the cases surveyed were placed into two groups as indicated in Table III.

The McBurney incision was employed in 69 per cent and 87.9 per cent of the cases in the early and more recent periods, respectively. Simultaneously the use of the right rectus incision declined from 29.2 per cent to 11.0 per cent. The use of the mid-line incision remained about the same for both periods.

The comparison of the mortality rate with each of the three types of incisions during a given period was as follows. During the 1928–1932 and 1937–1938 periods the McBurney incision showed a mortality rate of 19.2 per cent in patients with appendiceal peritonitis, the right rectus incision was associated with a mortality rate of 23.3 per cent and the mid-line incision with a mortality rate of 45.5 per cent. During the more recent era (1944–1945) the McBurney incision revealed a mortality rate of 3.4 per cent, the right rectus

TABLE III
INFLUENCE OF THE CHOICE OF INCISION UPON THE MORTALITY RATE OF ACUTE APPENDICITIS. THE MCBURNEY INCISION WAS ASSOCIATED WITH THE LOWEST MORTALITY RATE, THE RIGHT RECTUS INCISION WAS HIGHER, AND THE MID-LINE INCISION WAS HIGHEST OF ALL; "THE CLOSER TO THE MID-LINE THE INCISION IS MADE, THE HIGHER THE MORTALITY RATE." THIS DIFFERENCE WAS AS APPARENT IN THE PRE-CHEMOTHERAPEUTIC ERA AS IT IS NOW



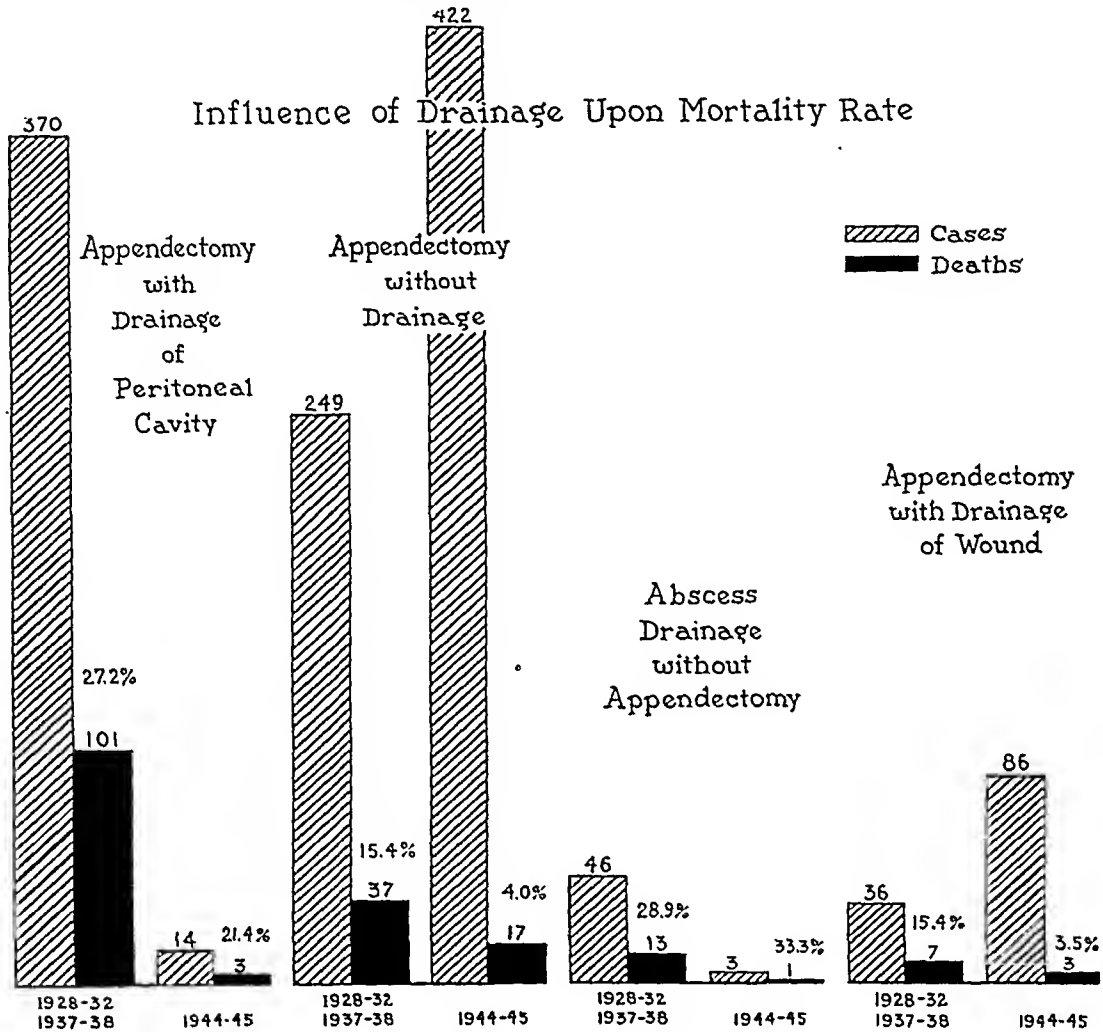
showed 12.0 per cent and the mid-line incision was 16.6 per cent. The final mortality rate differs in that it includes patients with far advanced appendiceal peritonitis never operated upon.

Influence of Drainage upon Mortality Rate. Table IV is presented with the purpose of illustrating the results obtained with appendectomy with and without drainage of the peritoneum, drainage of the peritoneum without appendectomy, and appendectomy with drainage of the

wound down to the peritoneum. Again, the material has been divided between the years 1928-1932 (Period A) and 1937-1938 and the years 1944-1945 (Period B). During Period A appendectomy with drainage of the peritoneal cavity for appendiceal peritonitis was employed in 370 cases with a mortality rate of 27.2 per cent. Appendectomy without peritoneal drainage was carried out in 249 such cases with a mortality rate of 15.4 per cent. An acute appendiceal mass was encountered

TABLE IV

INFLUENCE OF DRAINAGE UPON THE MORTALITY RATE OF ACUTE APPENDICITIS. PERITONEAL DRAINAGE WAS ASSOCIATED WITH THE HIGHEST MORTALITY RATE; DRAINAGE OF THE WOUND PRODUCED A MORTALITY RATE SLIGHTLY LESS THAN NO DRAINAGE AT ALL, BUT THE INCIDENCE OF WOUND INFECTION WAS LESS. CHEMOTHERAPY HAS NOT ALTERED THIS TREND.



in forty-six cases during this period and the operation was completed by insertion of a drain without appendectomy; this procedure carried with it a mortality rate of 28.9 per cent. During this same early period appendectomy for appendiceal peritonitis was performed and a drain was placed down to but not through the peritoneum and this resulted in a mortality rate of 15.4 per cent.

During Period B (1944-1945) appendectomy with peritoneal drainage was done in only fourteen patients and proved to have a mortality rate of 21.4 per cent. Appendectomy without peritoneal drainage was performed in 422 patients with a 4 per cent mortality rate. Drainage of an abscess

without appendectomy was done in only three patients with a death in one. Appendectomy with insertion of a drain down to the sutured peritoneum was executed in eighty-six patients with an attendant mortality rate of 3.5 per cent.

Influence of Chemotherapy upon Complications of Acute Appendicitis. During the years 1944 and 1945 it was routine practice with our surgical house staff to employ sulfonamides intraperitoneally in the wound, and parenterally when a postoperative peritonitis was apparent. Sulfanilamide crystals were used locally, sodium sulfathiazole given intravenously was the choice for parenteral use. Penicillin was also used in a limited number of patients but these

Advantages of Spinal Anesthesia for Appendectomy

1. Optimal relaxation
2. Quieting effect upon gastro-intestinal tract
3. Coughing reflex undisturbed (avoids aspiration)
4. Less post-operative care

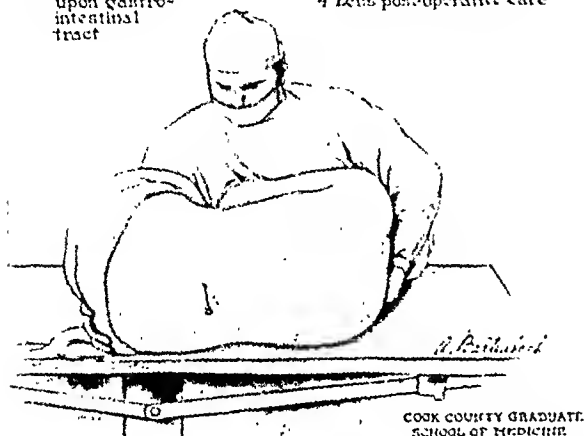
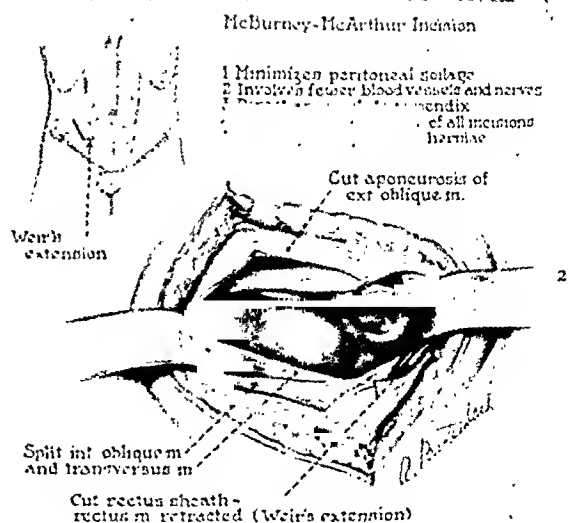


FIG. 1. The anesthetic of choice in the treatment of acute appendicitis.

FIG. 2. The incision of choice in the treatment of acute appendicitis.



were the more severe cases of generalized peritonitis and probably cannot be used for purposes of analysis.

Purulent wound infections were seen in 120 of the 592 patients treated with sulfa drugs; specifically, sulfanilamide was placed into the wound of sixty-nine of these patients. In eighty of the patients with wound infection a drain was not placed either into the wound or the abdominal cavity whereas in the remaining forty wound infections a drain was used, most frequently down to the sutured peritoneum.

In spite of intensive chemotherapy, abscesses were still encountered as a complication. These were pelvic in eight patients, sub-hepatic in four and intra-abdominal in two.

Wound evisceration occurred in three patients operated upon during 1944 and 1945. One of these occurred through a McBurney incision, one through a right rectus, and the third through a right paramedian. The latter patient expired.

Remaining complications consisted of a massive atelectasis in two patients and a so-called postoperative pneumonia in eight.

OPERATIVE PRINCIPLES

Choice of Anesthetic. The ideal anesthetic agent for an appendectomy per-

formed in the presence of acute inflammation would be one which disturbs the patient's immunologic processes the least, produces maximal relaxation, has a quieting effect upon the motility of the gastrointestinal tract and introduces the fewest postoperative complications. We believe that spinal anesthesia fulfills these criteria the best. We believe that a conscious patient is less apt to aspirate gastric content. Convulsions not infrequently seen under inhalation anesthesia of septic patients is less apt to occur under spinal anesthesia. In the very young and the very old it may be necessary to substitute general anesthesia, but even here induction with intravenous sodium pentothal is a worth while adjuvant. We have found the intrathecal introduction of novocaine or metycaine in doses averaging 1 mg. per pound of body weight (up to 150 mg.) produces approximately sixty and ninety minutes of anesthesia, respectively. This is given in the lateral recumbent position (Fig. 1) usually at the level of the third lumbar interspace. The total amount of drug is usually diluted up to 3 cc. with cerebrospinal fluid. To procure a satisfactory level of anesthesia the patient is placed in slight Trendelenburg position until the desired level is reached. Inasmuch as pain sensation re-

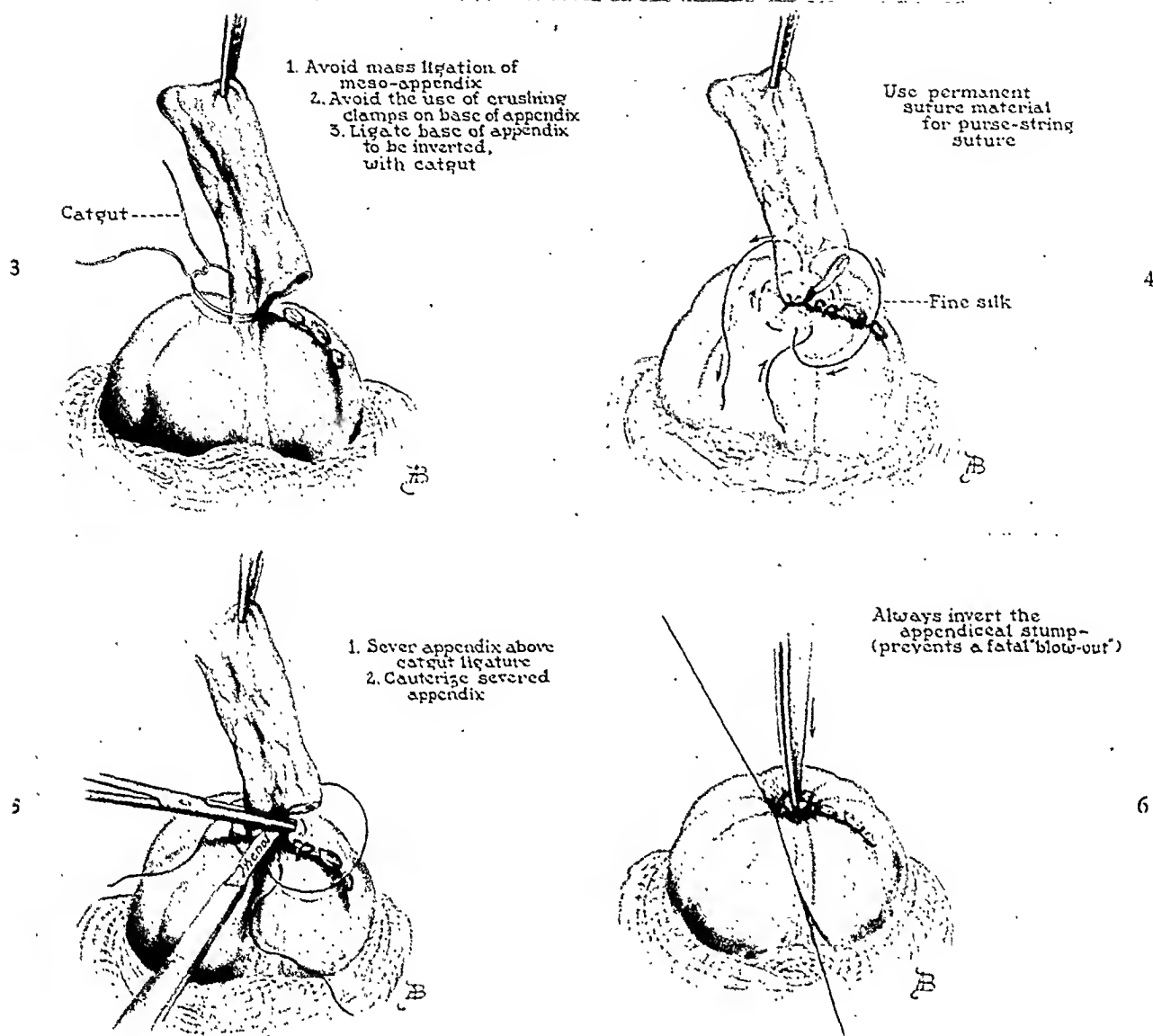


FIG. 3. The management of the meso-appendix and base of the appendix.

FIG. 4. Method of purse-string suture less important than the use of a permanent suture material for that purpose.

FIG. 5. Chemical cauterization of the severed appendiceal stump.

FIG. 6. Inversion of the base of the appendix—a "must."

turns long before motor sensation, the operation can frequently be continued under intravenous sodium pentothal should the "spinal" anesthetic time be exceeded.

Choice of Incision. The McBurney-McArthur muscle splitting incision has quite arbitrarily been favored. (Fig. 2.) This incision was employed in 87.9 per cent of the cases since 1937 by our resident staff and in private practice it has probably been even more popular. We consider the following to be the advantages of this incision: (1) The appendectomy can be

carried out with a minimal of peritoneal soilage. (2) There is less destruction of nerves and blood vessels than in the right rectus or battle-door incision. (3) This incision is more apt to place one directly over the appendix if it is made with the point of maximal tenderness in mind. (4) If the appendix is retrocecal, lateral extension of the incision will expose the lateral posterior wall of the cecum whereas upward extension of the battle incision would tend to be medial to the site of the pathological condition. (5) If the disorder lies

within the pelvis, Wier's extension (Fig. 2) into and along the lateral edge of the rectus provides adequate exposure. (6) It is associated with a lower incidence of postoperative hernia because of its anatomical nature.

Management of Meso-appendix. Mass ligation of the mesentery of the appendix was discouraged. McNealy has reported how such mass ligation distorts the ileocecal juncture and predisposes to subsequent obstruction of the terminal ileum. In acute appendicitis the mesentery is frequently indurated, friable and edematous, and reliance upon a single ligature is fraught with danger of subsequent hemorrhage. We believe further that sutures such as silk or cotton are apt to cut through this type of mesentery and, therefore, prefer fine chromic catgut as a series of interrupted ligatures for this purpose. (Fig. 3.)

Management of the Appendiceal Stump. Although every method of dealing with the base of the appendix is open to some theoretical objection, we have found the following principles to bear the test of experience. We believe in ligating the base of the appendix *without* application of a crushing instrument (Fig. 3); this avoids the danger of spillage and at the same time the danger of a slough due to pressure necrosis. The divided appendiceal stump is cauterized with phenol (iodine or electrocautery are equally acceptable). We have learned to consider inversion of the stump an obligatory part of the procedure. (Fig. 6.) It is the only way we know of preventing fatal fecal peritonitis due to a "blow-out." This we have witnessed time and again at necropsy following appendectomies for "interval" as well as acute appendectomies. The inversion should be carried out with a purse-string suture of some permanent material as advocated by Richter. (Fig. 4.) The exact modification of the purse-string suture that the individual operator wishes to use, we believe is unimportant, but that the material be a permanent one we are of the opinion is important. Whether the base of the cecum

is involved should not be a criterion, for then the operator should be placing his sutures far enough out into the cecum so that they are anchored to viable tissues. Finally, some form of peritonealization should be carried out (Fig. 7) whether it be by simply bringing over an ileocecal fat pad or a series of seromuscular sutures of the cecum. This will do much to prevent mechanical bowel obstruction from adhesions.

Drainage. The insertion of drains into the peritoneum is based upon the fallacious belief that such foreign bodies will siphon away exudate. Actually, within a matter of hours drains are so well walled off by fibrinous exudate that their function is soon lost, and instead of a drain we are left with a plug. We have long believed and have taught that the outcome of the operation was dependent more upon the degree of peritonitis than upon the type and number of drains inserted into the abdomen. Accordingly we have discouraged its use.

Drainage of the wound is a different matter. (Fig. 8.) Here extensive soilage is very prone to occur and the defense mechanisms are overbalanced by rather favorable culture media provided by extravasated blood, serum, fat and catgut sutures. Wound infections are, therefore, a frequent complication and it still appears that the most effect prophylaxis to that is a small drain inserted down to the sutured peritoneum. (Fig. 8.) Such a drain can be removed at the time the sutures are removed and does not delay convalescence.

Local Chemotherapy. The majority of the patients were treated in 1944 and 1945 by the application of varying amounts of sulfanilamide into the ileocecal area, the wound, and into the general peritoneal cavity when operative conditions permitted. Inasmuch as this was almost always supplemented by subsequent parenteral chemotherapy, it is difficult to appraise the value of its local use. However, it is difficult to consider 5 or 10 Gm. of sulfanilamide, locally applied, as self-

sufficient. Furthermore, in view of the inactivation of sulfanilamide by purulent exudate, the actual value of intraperitoneal and wound application is questionable. For this reason it might be well to use penicillin intraperitoneally because exudate does not affect it and a single dose will provide blood levels for five to six hours which are higher than equivalent doses given intravenously or intramuscularly.² However, the intraperitoneal use of penicillin awaits further experimental work.

Suture of the Wound. Our method of closure of an appendectomy wound is identical to that used in other abdominal wounds. The peritoneum is closed with fine interrupted silk on atraumatic needles. The internal oblique is loosely approximated with interrupted No. 32 stainless steel wire (Fig. 9) and the aponeurosis of the external oblique with the same type of suture, again interrupted. The skin is sutured with interrupted sutures of silk, dermal or nylon.

The use of permanent sutures is considered important for several reasons. There is much less exudation of serum and polymorphonuclear leucocytes than occurs with catgut; this we know minimizes chances for purulent exudation. Most infections of the wound are superficial to the aponeurosis of the external oblique or rectus fascia and wire sutures hold the tissues tight in the presence of purulent infection; we have rarely seen wire sutures extruded from a wound. In fact, on opening an occasional wound abscess we have been able to visualize the wire suture holding the fascia firmly together in the midst of the inflammatory exudate. Wire does not draw exudate through a tract as silk does for it is a solitary cylinder and not a wick composed of several twisted strands thereby acquiring the power of capillary attraction.

The use of permanent interrupted sutures further facilitates early ambulation which we employ wherever possible. By this we mean getting the patient out of bed at least twice on the first postoperative day and for increasing time intervals thereafter.

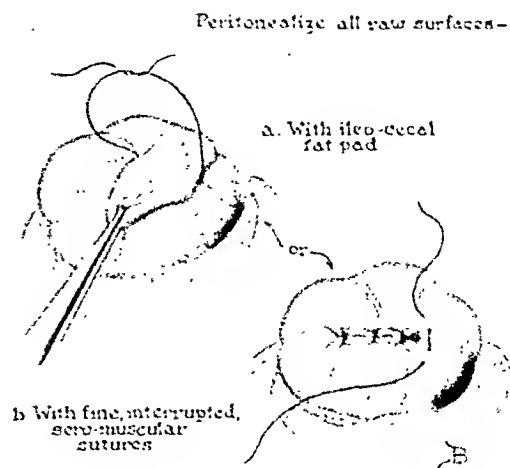


FIG. 7. Peritonealization of all raw surfaces.

The advantages of this are many and constitute an independent report³ but suffice it to say here that patients who do not have a generalized peritonitis, appendiceal abscess or ileus are permitted ambulation the next day after appendectomy. We consider this method of wound closure essential for that purpose.

Postoperative Requirements. (1) Patients suffering from appendiceal peritonitis receive a minimum of 3,000 cc. of parenteral fluids per day plus whatever additional is lost through intragastric suction. Part of this fluid intake should supply protein either in the form of whole blood, plasma or amino acids. Not more than 1,000 cc. of this amount of fluid should be saline unless there is marked losses due to suction. The fluid intake should be sufficient to insure a twenty-four-hour urine volume for the adult of not less than 1,000 cc. with a specific gravity less than 1.015.

(2) Intragastric suction (we favor the Levine tube) is an important adjuvant in the treatment of appendiceal peritonitis. Its chief purpose is to prevent or decrease distention, its effect is explained by the important observation that the bulk of intestinal gases comes from swallowed atmospheric air. Such suction is maintained until signs of returned peristalsis is apparent as judged by active bowel sounds, passing of flatus, bowel move-

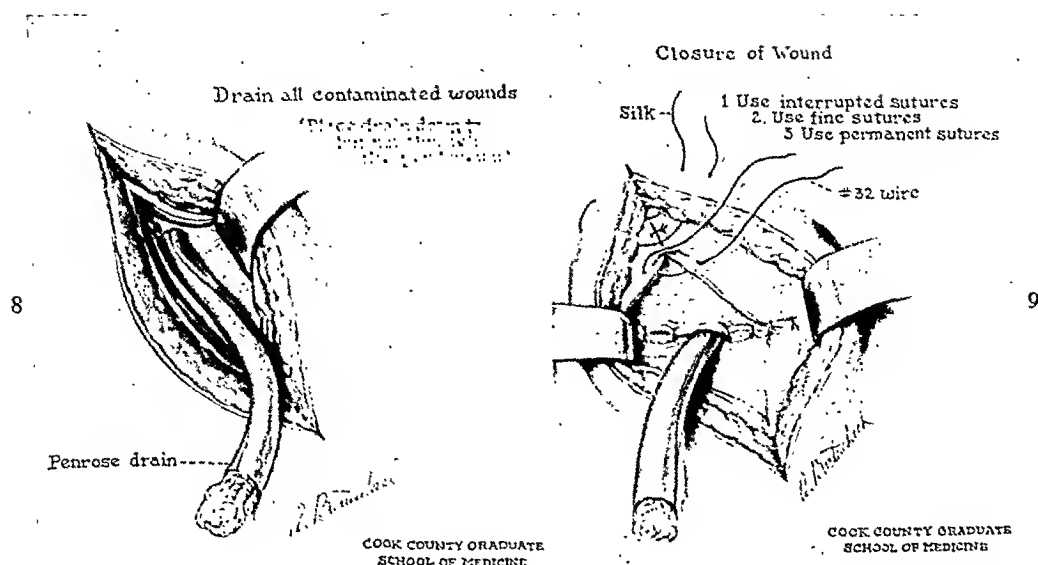


FIG. 8. Insertion of a cigarette drain down to the peritoneum decreases wound infections.

FIG. 9. Use of fine permanent sutures throughout all layers in closure of the wound.

ments or actual demonstration of a "positive pyloric balance" when a careful record of fluids taken in per os and recovered by suction are compared. This usually occurs on the third or fourth postoperative day. We have rarely resorted to the use of the Miller-Abbott tube to treat the ileus of appendiceal peritonitis; however, its use in the decompression of a mechanical obstruction complicating an appendectomy may be crucial and avoid a second operation.

(3) Chemotherapy is a routine measure in the treatment of appendiceal peritonitis. We have utilized either sodium sulfathiazole or sodium sulfadiazine intravenously. To maintain a blood level between 8 and 12 mg. per cent from $2\frac{1}{2}$ to 5 Gm. per day are sufficient. With the use of sulfadiazine in preference to sulfathiazole, and careful attention to renal output, we have rarely encountered a sulfa anuria. More recently penicillin has been made available and it has been used in conjunction with sulfonamide therapy rather than in place of it. Its effect is yet to be evaluated.⁴

(4) Oxygen inhalation, using the B.L.B. mask to achieve 100 per cent concentrations has been used for the more severe cases of peritonitis. The indications and benefits are manifold: the anoxemia, tachycardia, shock and bowel distention are

all features of generalized peritonitis which suggest oxygen therapy.

(5) Intravenous vitamin therapy is indicated by virtue of the depletion of vitamins B and C by such an acute febrile illness, to improve the metabolism of carbohydrate administered by vein, and to promote more satisfactory wound healing.

(6) We do not administer peristaltic stimulants such as prostigmine, pitressin, pilocarpine or irritating enemas. An ileus is a physiological response to a peritonitis which will respond spontaneously as soon as the peritonitis is brought under control. The use of drugs or enemas is very much like whipping a tired horse, if one may use such a homely analogy.

(7) The treatment of the intra-abdominal complications of acute appendicitis cannot be retold here, but has been described previously by one of us.⁵ These require far greater skill and judgment than the removal of the appendix and it is well for the attending surgeon to be familiar with these complications for we doubt that the era of chemotherapy will entirely prevent them.

COMMENTS

Although we have been teaching the principles of the treatment of acute ap-

pendicitis to our house staff long before such data as we have accumulated here were available, it remains to be seen whether our statistics justify the position we have taken. Let us list these principles again and see what experience within one institution has shown.

Most important in the treatment of appendicitis is the performance of the appendectomy prior to perforation. It is apparent from our own data (Table 1) that the improvement in the mortality rate for the treatment of acute non-perforated appendicitis is not statistically significant. In other words, if we could be certain that all acute appendicitis would reach us prior to perforation, we could assure the patient a mortality rate well under 1 per cent without recourse to any of the modern therapeutic adjuncts available. This obviously is as strong an argument for early appendectomy as we need. Nevertheless, we noted that in 1945, approximately 40 per cent of these patients had taken cathartics prior to admission; and better than one-fourth of the appendices had perforated!

The most striking improvement in the treatment of appendicitis has occurred in the treatment of appendiceal peritonitis. For in a period of approximately fifteen years the mortality rate from acute appendicitis with perforation has dropped from 26.4 per cent to 13.9 per cent, a decrease of almost one-half. Inasmuch as the operative technic for the removal of a perforated appendix is obviously the same as for a non-perforated appendix, the explanation for the marked improvement in the mortality rate of the former lies in the postoperative care and not surgical technic. Furthermore, inasmuch as the greatest improvement in the treatment of appendiceal peritonitis occurred since 1938, when blood was already available to our patients, it would appear that the greatest factor was chemotherapy. The benefits of chemotherapy in the treatment of appendicitis has adequate confirmation.⁶⁻¹³

Another teaching principle has been to

avoid operative intervention in the patient with an acute appendiceal abscess based upon the concept that such a patient is localizing his inflammation well and that the leak from the intestinal tract will be sealed by this means. Operation in this type of case may result in what has been well termed an "induced" peritonitis. Analyzing the record (Table II) one observes that the former mortality rate of 18 per cent for operated cases was reduced to 4.2 per cent when conservative measures were utilized; more recently, in spite of chemotherapy, the mortality rate in such cases operated upon was 8.5 per cent whereas those without surgery was 3.1 per cent. Presumably non-surgical intervention rather than chemotherapy is the answer to the management of the patient with an acute appendiceal mass. The value of this precept has progressed to the point where cancelling the operation is advised if a mass becomes more definitely palpable under anesthesia, or simply draining the abscess if one is inadvertently encountered on opening the peritoneum.

The McBurney-McArthur muscle splitting incision has been favored for a number of anatomical reasons. Both in the periods prior to 1938 and more recently, this incision has been associated with a significantly lower mortality rate than any other. In fact we have used the maxim that the closer to the mid-line the appendectomy is performed, the higher the mortality rate. While it is true that right rectus and mid-line incisions are utilized more often when the diagnosis is in doubt, yet this alone cannot account for a recent mortality rate with the McBurney-McArthur incision approximately one-fourth of either of the other two. If one remembers that one can extend this incision medially to achieve the advantages of the right rectus incision, then certainly there remains little advantage in exposing a patient to the increased mortality risk.

Although we have presented other evidence discouraging the use of intraperitoneal drains, undoubtedly its influence upon

the mortality rate will be the most convincing. Here we found, in every period studied, the highest mortality rate for patients with peritoneal drains, considerably lower mortality rates for those not drained, and still lower mortality rates for those with a drain placed down to the sutured peritoneum. We acknowledge the greater tendency to place peritoneal drains in patients with the more severe grades of peritonitis, but in 1944 and 1945 the majority of the patients with appendiceal peritonitis did not have intraperitoneal drains and there was a marked lowering of the mortality rate whereas the few who did have such drains inserted showed little improvement in the mortality rate. The value of inserting drains into the wound (not the abdominal cavity) is further attested by the fact that two-thirds of the patients with wound infections did not have wound drainage.

SUMMARY*

1. The mortality rate for the removal of acute non-perforated appendices was well under 1 per cent, without significant improvement in recent years.

2. A lowering of the mortality rate from 26.4 per cent to 13.9 per cent has occurred in the treatment of acute perforated appendices with appendiceal peritonitis; this is attributed chiefly to chemotherapy.

3. The greatest improvement in the treatment of acute appendiceal abscesses occurred from non-operative intervention.

4. The McBurney-McArthur muscle-splitting incision is associated with the lowest mortality rate; the closer the incision is made to the mid-line, the higher the mortality rate.

5. Appendectomy with drainage of the

* In a recently completed series of 108 patients operated upon for acute suppurative appendicitis and treated prophylactically with penicillin at the Cook County Hospital, Drs. Griffin, Silverstein, Hardt and Seed¹⁵ report only one death. This represented a marked improvement over a 4 per cent mortality rate reported by them for all patients operated upon. Our statistics included all cases, both operated and non-operated. The latter type is frequently moribund on admission and materially affects the mortality rate.

peritoneal cavity was associated with the highest mortality rate.

6. Appendectomy without drainage of the peritoneal cavity showed a much lower mortality rate than similar cases which were drained.

7. Appendectomy with drainage of the wound (usually for a perforated appendix) showed a mortality rate slightly lower than appendectomy without drainage but a much lower incidence of wound infections.

8. The surgical principles thought to be of value in the treatment of acute appendicitis are discussed in full detail.

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ACUTE SURGICAL CONDITIONS OF THE ABDOMEN: CONGENITAL LESIONS

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IN any consideration of congenital lesions it should be remembered that anomalies tend to be multiple, and when one is found thorough search should be made for others which may be more serious. In 15 per cent of all types of congenital malformations multiple major defects exist which are not amenable to surgical treatment and the prognosis is hopeless.² The majority of serious maladies of early infancy are due to mechanical lesions or congenital lesions of a mechanical nature rather than any histopathologic alteration such as neoplasia or a primary inflammatory process.

The following discussion omits many congenital lesions of the abdomen as they do not constitute an acute surgical condition.

CONGENITAL HYPERTROPHIC PYLORIC STENOSIS

Congenital hypertrophic pyloric stenosis is the most common acute surgical condition of the newborn. The cause of this interesting disease still remains unknown; however, there seems to be an hereditary factor as it occasionally occurs among two or more members of the same family. The ratio of males to females affected is 4:1. There is hypertrophy of the circular muscle of the pylorus with an actual increase in the number of muscle fibers. This pyloric musculature is of variable size, but it usually forms a smooth, bulbous mass about 2 by 1.5 cm. The stenosis is caused by the large, firm, unyielding mass of muscle compressing the mucosa and greatly decreasing the lumen in this region.

Symptoms. Vomiting usually begins when the infant is about two weeks old, seldom before. It begins gradually but soon

becomes forceful and projectile and occurs after most feedings. As the obstruction is above the papilla of Vater, the vomitus does not contain bile. This is important in differentiating other obstructive lesions. The child usually is not seen until four to six weeks of age. By then the amount of stool has decreased, and with continued decrease of fluid and caloric intake, there are loss of weight and dehydration. Wrinkling of the skin and loss of elasticity may be marked. Electrolytic imbalance may quickly supervene with alkalosis leading to tetany.

Physical findings. A small mass almost always can be palpated in the right upper quadrant when the abdomen is relaxed. Relaxation can be produced by laying the baby on his abdomen and gently palpating with the hand under the infant. Feeding the baby often will relax the abdomen and there is usually a brief period of relaxation immediately after vomiting.

Roentgenologic examination reveals a large, gas filled stomach with little gas in the intestine. It is most rare that barium studies are indicated.

Differential diagnosis. Congenital hypertrophic pyloric stenosis must be differentiated from pylorospasm in which the vomiting tends to occur in spells and is not progressive. There is often associated hypertonicity with pylorospasm and the symptoms can be relieved by atropine. Unsuitable formulas that are too large or too concentrated may cause postprandial regurgitation, which may be confused with pyloric stenosis.

Stenosis or atresia of the duodenum or intestine usually produces emesis very soon after birth. The vomitus in such cases

usually contains bile. Atresia or stenosis of the esophagus may be associated with tracheoesophageal fistula with resulting respiratory complications.

Incomplete rotation of the intestine, which obstructs usually at the duodenum below the papilla of Vater, produces vomiting within the first twenty-four to forty-eight hours after birth. The vomitus contains bile.

Intracranial hemorrhage or traumatic injury occurring at birth or later may cause emesis but this is not necessarily associated with feeding and occurs at irregular intervals. Other neurologic signs usually are present to aid the differentiation.

Treatment. Although congenital hypertrophic pyloric stenosis is an acute surgical condition, operation should be delayed until the child's nutritional and electrolytic state is improved as much as possible. This often takes two or three days but the time is well spent. Glucose should be given intravenously in 5 per cent or 10 per cent concentration, 10 cc. per pound of body weight being given twice daily, and physiologic saline solution should be given by hypodermoclysis in amounts up to 15 cc. per pound of weight. Thickened feedings should be given during this preparatory period. Atropine may be used, but is of questionable value.

Technic. Anesthesia should be sufficient so that the abdomen is relaxed during the entire operation. Drop ether is the anesthetic agent of choice and affords relaxation with a good margin of safety.

Through a right rectus incision the pyloric region is exposed and the bulbous mass is held between the thumb and index finger. A longitudinal incision is made through the muscle on the anterior surface down to the mucosa. The muscle then is separated more with a small hemostat until the mucosa bulges between the cut edges of the muscle. When the muscle is incised it should be done with great care as the muscle at the distal or duodenal end of the bulbous mass very abruptly thins out and consequently the duodenal mucosa can be

entered very easily. If the mucosa is incised it should be closed and covered with a piece of omentum.

Closure of the abdomen should be done accurately and carefully. The tissues often are like spider web and not much stronger. Disruption can occur even two or more weeks after closure. It is best to use fine interrupted sutures and several through-and-through retention sutures passing through the skin, muscle and peritoneum.

Postoperative care. The child may be fed soon after consciousness is regained. One ounce (30 cc.) of fluid should be given every two hours starting with water for four or five feedings and half-strength formula for four or five feedings; the strength and amount of formula then should be increased gradually so that the full formula is fed about forty-eight or sixty hours after operation.

In addition to these feedings it is best to give fluids parenterally for the first two or three days so that the child receives an over-all total of 3 ounces (90 cc.) of fluid for each pound of weight.

The relationship between fluid exchange and extracellular fluid in an infant weighing 7 kg. compared to an adult weighing 70 kg. is pictured in figure 1, taken from Gamble.¹ The relatively larger surface area of an infant prescribes a basal rate of heat production per kilogram which is approximately twice as rapid as in the adult. Therefore, insensible water loss per kilogram is twice as large. Minimal water expenditure per day by the infant is 300 cc. and by the adult is approximately 1,400 cc. Extreme dehydration thus can quickly develop in an infant with insufficient intake, especially in the presence of vomiting, when loss of electrolytes further complicates the fluid imbalance.

MECKEL'S DIVERTICULUM

Meckel's diverticulum is the vestige of the vitelline duct, which had opened into the ileum. A small cord of tissue occasionally connects the diverticulum to the umbilicus and very rarely a fistula is

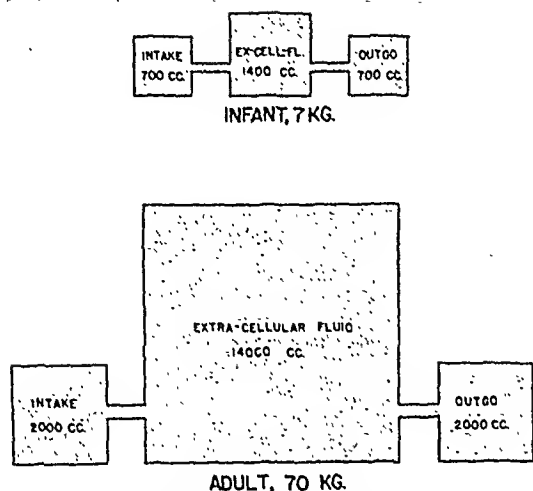


FIG. 1. The relationship of water exchange to extracellular fluid in an infant weighing 7 kg. and an adult weighing 70 kg. The rapidity with which dehydration can develop in an infant can be seen in this diagram. Intake of fluid in the infant is relatively large and amounts to half the total extracellular fluid. Intake in the infant also is one-third the intake of an adult weighing 70 kg. (From GAMBLE, J. L. Chemical anatomy, physiology and pathology of extracellular fluid: a lecture syllabus. Harvard Medical School, 4th ed. Cambridge, Massachusetts, 1944. Harvard University Press.)

present. Ladd and Gross¹¹ reported six cases of intestinal obstruction caused by a band running to the umbilicus. Figure 2 shows some of the forms in which the remains of the vitelline duct may be found.

Meckel's diverticulum occurs about twice as frequently in males as in females and usually arises on the antimesenteric side of the terminal ileum $1\frac{1}{2}$ feet to 3 feet (46 to 91 cm.) proximal to the ileocecal valve. It varies in size from $\frac{1}{2}$ inch to 5 inches (1.3 to 13 cm.). The lining epithelium contains gastric mucosa in about 50 per cent of the cases. Occasionally, duodenal, pancreatic or colonic tissue can be identified. This heterotopia accounts for some of the symptoms. Unexplained hemorrhage from the intestinal tract fairly frequently is from a bleeding peptic ulcer occurring in a Meckel diverticulum.

Symptoms resembling those of appendicitis can be caused by a diverticulum which may become inflamed and perforate. A Meckel diverticulum always should be looked for when a normal appendix is

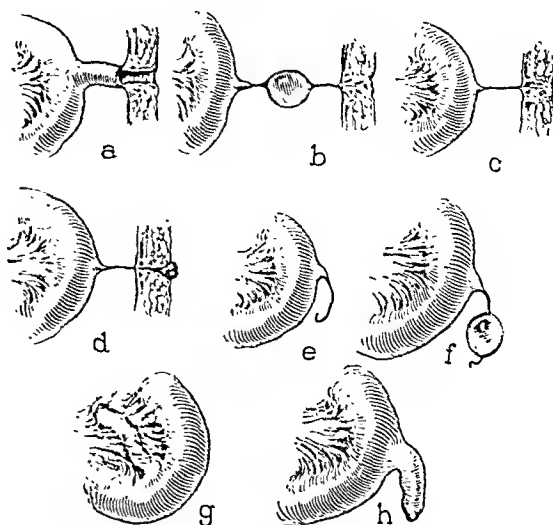


FIG. 2. Forms in which the remains of the vitelline duct may be found: a, patent duct opening onto the abdominal wall at the umbilicus; b, the duct occluded at its ends so that a cyst is formed somewhere in its length; c, the duct obliterated but remaining attached to the umbilicus; d, the duct remaining attached to the umbilicus and having intestinal mucosa at its outer end; e, the duct obliterated and hanging with a free end within the abdominal cavity; f, the duct hanging within the abdominal cavity and forming a cyst; g, the duct lying within the mesentery of the small intestine, and h, the duct remaining as a small, patent projection from the ileum. (From DIXON, C. F. and STEWARD, J. A. Diverticulum with hemorrhage; omphalo-adenoma. *S. Clin. North America*, 12: 1025-1031, 1932.)

found with symptoms of acute appendicitis. Volvulus may occur around a Meckel diverticulum or the diverticulum may become twisted and infarcted. It also may be the leading point of an intussusception.

Figure 3 shows a Meckel diverticulum in an eleven year old boy which looped around the root of the mesentery forming a half-hitch with itself and obstructing the lower third of the ileum. The knot was so tight it was difficult to untie at the time of necropsy.

Treatment. If a normal appearing Meckel diverticulum is found which is small, is unattached to the abdominal wall or to other organs, and has an adequate lumen, it should not be removed. If it has produced symptoms and should be removed, it should be excised in such a manner as to leave an adequate lumen. This is usually accomplished by excision

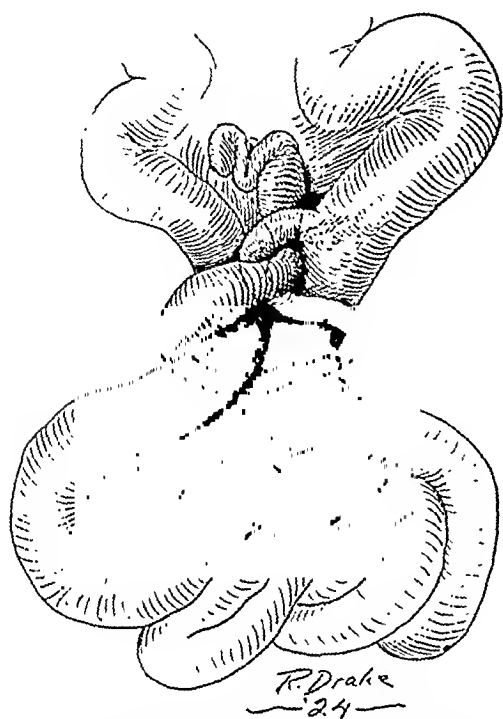


FIG. 3. A Meckel diverticulum looped around the root of the mesentery and forming a half-hitch with itself.

with an elliptical incision in the long axis of the ileum and suturing the transverse axis. Closure with a purse-string suture should not be attempted.

If an intussusception is present an attempt should be made to reduce it. If the symptoms are of more than thirty-six hours' duration, the intussusception should be fixed with interrupted sutures so that it cannot advance and a short-circuiting enterostomy or ileocolostomy should be carried out.¹³ The invaginated portion then may slough out through the lumen of the intestine. The mortality rate is much lower if this procedure is used than if resection and anastomosis are performed in acute cases.

DUPLICATIONS OF THE GASTRO-INTESTINAL TRACT

Duplications of the gastro-intestinal tract are very rare but should be remembered and recognized as they may lead to acute surgical complications. Inclusion cyst, enteric cyst and enterogenous cyst are, in reality, duplications of some portion

of the gastrointestinal tract, although they may not duplicate that part to which they are connected or attached. Duplications of the gastrointestinal tract are most frequently found in the small intestine. The structure has one or two muscular layers and is lined with mucosa. At times the lumen communicates with the lumen of the gastrointestinal tract. Lewis and Thyng¹² frequently found duplications of the fetal mammalian alimentary tract, which normally regress. These may represent pinched-off cells of the fetal intestinal tract. Triplication of the colon has been reported by Gray.⁶

The duplication usually contains clear fluid and is firmly adherent to the normal stomach, intestine or colon with no line of cleavage between the duplication and the normal organ. In removing such a structure, it is usually necessary to resect the adjacent normal portion of the gastrointestinal tract, as the duplication cannot be peeled or dissected out as can a mesenteric cyst, with which it may be confused.

Symptoms. The symptoms are usually those of obstruction, which may be mild and repeated over a long period or may be acute, occurring soon after birth. The symptoms are caused by encroachment on the normal intestinal lumen by accumulation of secretions in the blind duplication. This enlargement may occur between the leaves of the mesentery and impair the blood supply to the normal intestine.

Treatment. Occasionally an opening made between the duplication and the adjacent portion of the intestinal tract will adequately drain the part without later filling with food or intestinal contents. However, because of the size of the lesion, common blood supply, and lack of cleavage planes, resection of the duplication and adjacent gastrointestinal tract usually is necessary.

Griess, Dixon, Weber and Barger⁷ recently reported a case of complete duplication of the colon. The patient was a twenty-seven year old woman, who had been operated on elsewhere for intestinal obstruction at four years

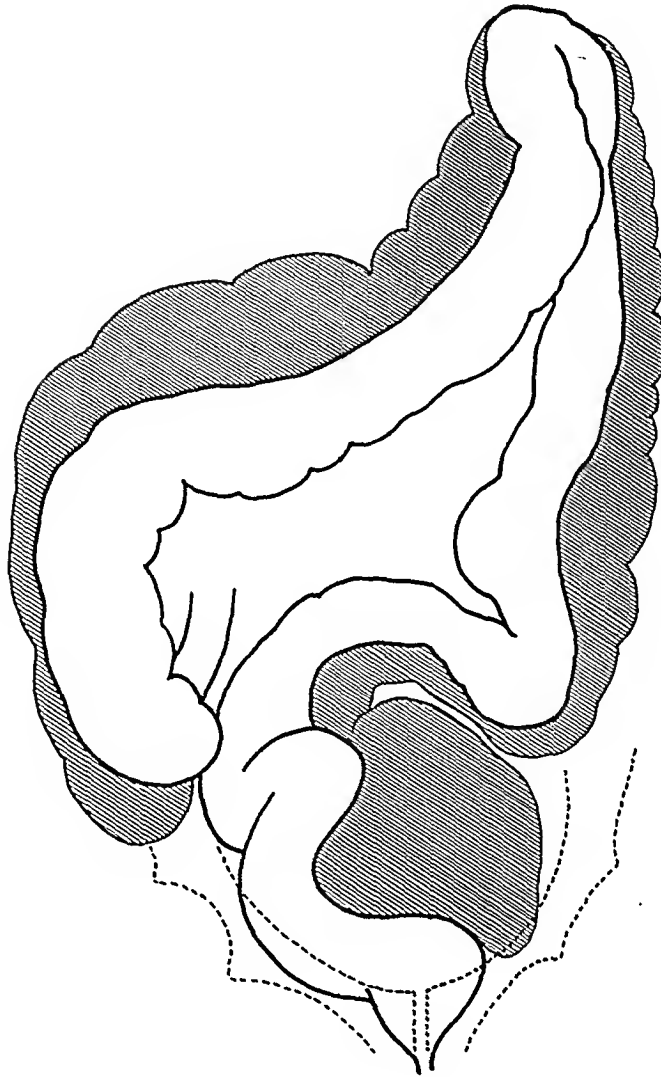


FIG. 4. Diagram of roentgenogram of colon showing radiopaque concretion in the blind duplicated colon. (From WEBER, H. M. and DIXON, C. F. Duplication of the entire large intestine (colon duplex): report of case. *Am. J. Roentgenol.*, 56: 319-324, 1946.)

of age and twenty-three years of age. At the time of the last obstruction the surgeon drained what appeared to be a cyst. Two appendixes, one of which was gangrenous, were removed at twenty years of age.

The patient had had symptoms of partial obstruction for one month before the present admission. Physical examination revealed a double infantile uterus, a vaginal septum, and a pelvic mass. There were two draining fistulas in the scar in the left lower quadrant. Roentgenologic examination showed a complete duplication of all segments of the colon, including the cecum and rectum. (Figs. 4 and 5.) Both colons seemed to be complete morphologically, but the one without external communications was filled with what appeared to be a fluid, calcareous material. The rectum

with the external communication was displaced by the mass composed of the other rectum.

At operation the patient was found to have congenital absence of the right kidney, two uteri and the double colon. The two colons arose from the same mesentery. The fistulas were removed and a communication was made between the two colons by resecting 8 or 10 inches (20 or 25 cm.) of each in the sigmoid region as an exteriorization operation. Later clamps were applied to the spurs and the colonic stoma was closed.

IMPERFORATE ANUS

As this symposium is limited to acute abdominal surgery, a complete review of imperforate anus will not be given.

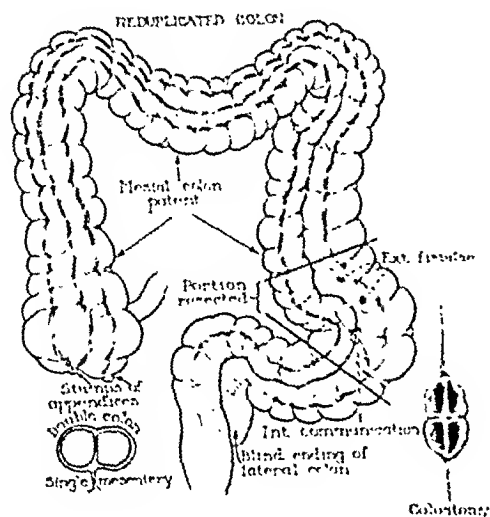


FIG. 5. Double colon, as found at operation.

It is important to determine the position of the blind rectal pouch, so that the proper surgical procedure may be decided on. Holding the infant head down as described by Wangenstein and Rice¹⁷ with roentgenograms taken in both the lateral and the anteroposterior position is very helpful. Roentgenograms taken within the first twelve to twenty-four hours after birth may not be satisfactory as the colon may not yet contain sufficient gas.

If there is an anal dimple which bulges when the infant cries, perforation of the separating membrane probably will establish continuity. If repair by the perineal route cannot be carried out, immediate abdominal reconstruction should not be attempted. Transverse colostomy can be done if there is a possibility of later pull-through procedure. However, it is well to have the stoma as near the end as possible because of the collection and inspissation of mucus in the blind loop when transverse colostomy is done.

FAILURE OF INTESTINAL ROTATION (MALROTATION)

During the embryonic development of the human intestine wide change in position takes place before the adult arrangement is obtained. In the 7.5 mm. embryo the umbilical loop has been formed and is

herniated into the umbilical cord as a result of intra-abdominal pressure and increased length of the intestine. By the time the embryo is 10 mm. in length the umbilical loop has turned about 90 degrees to the right, that is, counterclockwise. The increase in length and extension of the colon so that the cecum occupies the right lower abdominal quadrant may not be finished until the first year of extra-uterine life.

Congenital anomalies associated with failure of intestinal rotation and capable of producing serious digestive disorders of a mechanical nature are known to exist. These anomalies may be divided into two groups: (1) the group in which there is failure of fixation of the small intestine, making possible volvulus of the entire mass of the intestine in a clockwise or counterclockwise direction about the mesenteric pedicle and (2) the group in which there are persistent congenital mesenteric bands producing intermittent or absolute intestinal obstruction.

During the development of the embryo mesenteric bands have a definite normal function in the rotation of the intestinal tract. Wakefield and Mayo¹⁶ have shown that the maintenance of these mesenteric bands after birth may produce intestinal obstruction. (Figs. 6, 7 and 8.) The complexity of rotation can be visualized by study of the intestine of the cat. Figure 9 shows the arrangement of the intestine and mesentery in the cat comparable to that of the human embryo before rotation begins within the abdominal cavity. The mesentery between the closely approximated segments of intestine (A and B) is the duodenocolic isthmus. The mesenteric artery is on the left side of the vein and the duodenum is intraperitoneal. In Figure 10 the midgut has started its rotation about the duodenocolic isthmus (A and B), which is now in the vertical axis. In figure 11 the final arrangement is seen, as is found in the normal adult human. The small intestine now occupies the left side of the abdomen and the portions indicated by A and B have changed from right to left and from

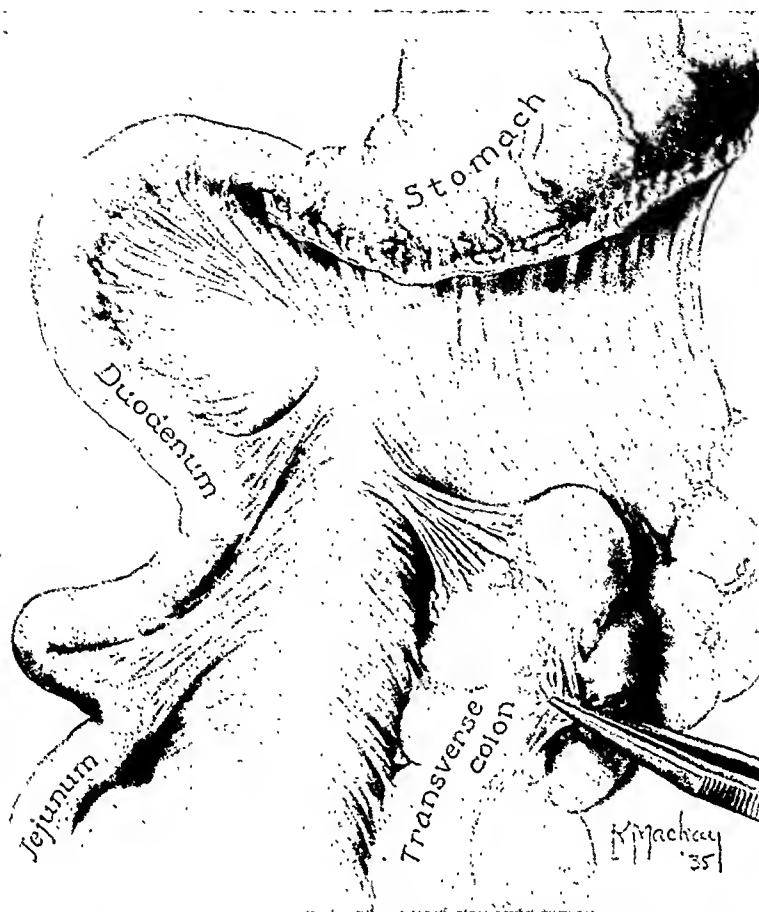


FIG. 6. Congenital mesenteric bands causing duodenal obstruction in a woman forty-two years old. There is malrotation of the colon and the duodenum is intraperitoneal. (From WAKEFIELD, E. G. and MAYO, C. W. Intestinal obstruction produced by mesenteric bands, in association with failure of intestinal rotation. *Arch. Surg.*, 33: 47-67, 1936.)

left to right respectively. The ileum now enters the colon from the left and the descending portion of the duodenum is dorsal to the colon. The superior mesenteric artery, which formerly occupied the duodenocolic isthmus, now passes anterior to the duodenum and is on the right side of the vein.

Figure 6 shows the mesenteric bands found in a forty-two year old woman who had had repeated attacks of abdominal pain and vomiting since childhood. The duodenum was found to be intraperitoneal and angulated by traction bands. The transverse colon was found to be attached to the dorsal portion of the parietal peritoneum in the upper part of the abdomen.

Figure 12 shows the small intestine twisted around an abnormally placed colon. The unusual length and mobility of the

mesentery of the small intestine combined with the abnormal position of the colon, resulted in volvulus. The inset shows the colon in the left side of the abdomen and the intraperitoneal position of the duodenum.

Gardner and Hart⁵ reported 105 cases collected from the literature of anomalies of the intestinal tract causing obstruction. In eighty-eight of the 105 cases the condition was the result of volvulus of the entire mesentery. Ladd and Gross¹¹ have called attention to the importance of recognizing the obstruction of the descending duodenum that usually is present with volvulus of the midgut or entire mesentery. This duodenal obstruction is caused by an overlying cecum or a persistent mesenteric band. Unless this is severed, the duodenal

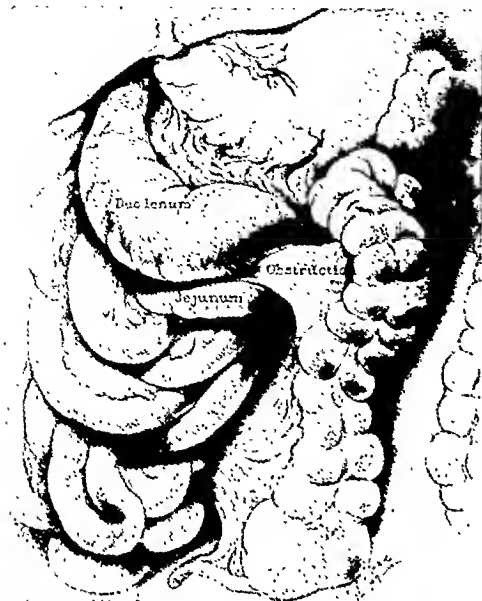


FIG. 7. Malrotation of the colon, which occupies the left side of the abdominal cavity. There is a persistent congenital mesenteric band obstructing the duodenum. The duodenum is entirely intraperitoneal. Search always should be made for this congenital band after one has reduced a volvulus of the small intestine associated with malrotation of the colon.

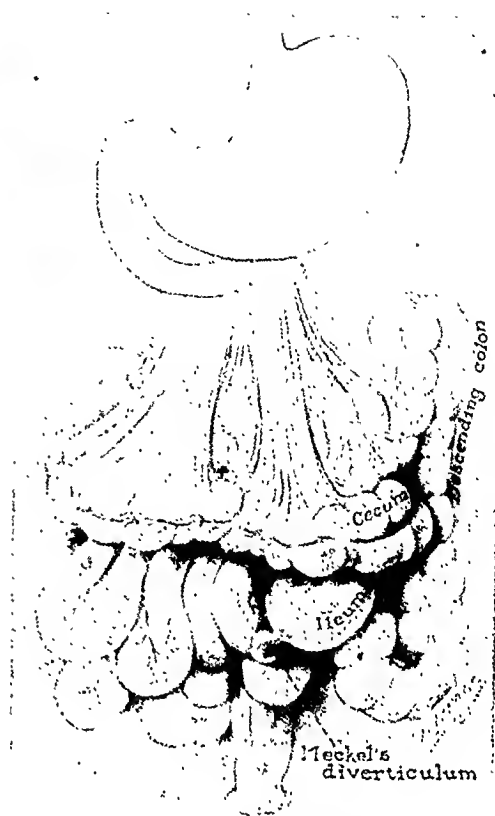


FIG. 8. Malrotation of colon in man twenty-four years old. The malrotation has produced intermittent obstruction of the small bowel since infancy.

obstruction persists even though the volvulus has been corrected. (Fig. 7.)

Symptoms. Many cases of incomplete rotation are asymptomatic and may be found only incidentally during roentgenologic examination or at the time of an abdominal operation.

Symptoms, if present, are those of obstruction and depend on the location and degree of obstruction. In the majority of cases the infant is seen within the first two or three months after birth because of vomiting due to duodenal obstruction. The obstruction is usually partial and below the papilla of Vater so that bile is present in the vomitus and there is passage of stool.

Dehydration occurs rapidly and may be severe. If volvulus occurs there may be considerable distention from entrapped gas. The temperature may reach 104° to 105°F . from either the dehydration or infarction associated with a volvulus.

Barium studies are usually unnecessary and undesirable in acute cases because of the danger of aspiration into the lungs or

inspissation in the intestine. In older children and adults with recurrent attacks of obstruction or vague abdominal symptoms, studies by barium enema and barium by mouth should be carried out.

Ladd and Gross¹¹ cited a case of a twenty-one month old boy with symptoms of several months of recurrent attacks of abdominal swelling associated with vomiting or diarrhea diagnosed as celiac disease. In reality the symptoms were due to volvulus of the entire midgut. In their opinion all persons who have celiac syndrome should undergo barium studies to detect any malrotation, as surgical correction of the latter may relieve the patient's symptoms.

Treatment. Adequate preparation with fluids, electrolytes and blood if necessary should be carried out in all cases. A long right rectus incision to afford good exposure should be made. In an infant an obstruction of the duodenum due to a mesenteric

band often will be found. This is usually associated with a volvulus of the entire mesentery.

If the right half of the colon is not seen on opening the abdomen but only distended and probably bluish, discolored small intestine, a volvulus of the midgut should be recognized. It is easily mistaken for a herniation of small intestine through a portion of mesentery. The incision should then be enlarged, if necessary, and the small intestines delivered onto the abdomen where the true nature of the process can be seen. The volvulus is usually clockwise and should be unwound before the intestines are replaced. The mesenteric band compressing the duodenum, which almost always is present, should be severed, as closure at this time probably will result in death unless the band is cut. No attempt should be made to rotate the bowel to its normal position, but the right half of the colon should be allowed to rest in the left side of the abdominal cavity. The small intestine can then be inspected again for color and viability before the abdomen is closed.

If there is any question of viability of a segment, 100 per cent oxygen can be administered and the bowel observed.¹ If the color of the bowel definitely improves it should be viable.

If the ascending colon and transverse colon are seen in the right upper quadrant on opening the abdomen, the obstruction probably is due to a mesenteric band between the ascending colon and abdominal wall compressing the duodenum. This band should be cut and the cecum and ascending colon allowed to rest in the left side of the abdominal cavity with no attempt to rotate the colon to its normal position.

In older children and adults obstructing mesenteric bands are usually found in the region of the duodenum. (Figs. 6 and 7.) Occasionally a mobile cecum which has caused symptoms will be found lying in the right lower quadrant with an unattached mesentery. The peritoneal band between the hepatic flexure and the abdominal wall may be incised, permitting the right side

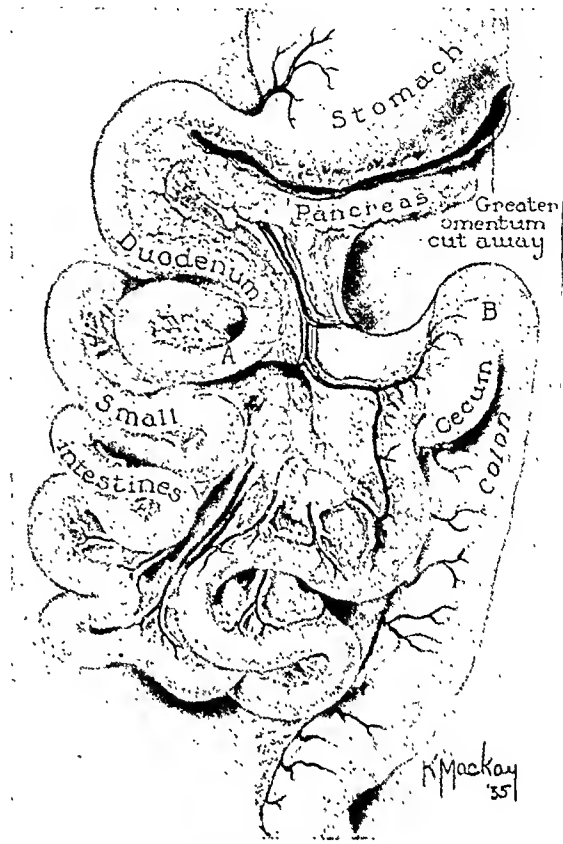


FIG. 9. Intestines of normal cat. This is the relative position of the human midgut before rotation begins. A-B is the duodenocolic isthmus, around which the midgut rotates. (From WAKEFIELD, E. G. and MAYO, C. W. Intestinal obstruction produced by mesenteric bands, in association with failure of intestinal rotation. *Arch. Surg.*, 33: 47-67, 1936.)

of the colon to fall to the left side of the abdominal cavity. If the mesentery of the ascending colon is normally attached, the mobile cecum can be secured in the right lower quadrant with a few interrupted sutures.

CONGENITAL PERITONEAL DEFECTS

During the normal rotation of the midgut, the peritoneum of the mesentery fuses with posterior and lateral abdominal structures. Abnormal openings or rents may result from lack of complete fusion. Loops of bowel may pass through such an opening, forming an intra-abdominal hernia, which may become incarcerated. The most common site for a congenital rent is in the mesentery of the terminal ileum. (Fig. 13.) Occasionally there is a defect in the ascending mesocolon.



FIG. 10. Beginning of rotation. Duodenocolic isthmus (A-B) is now in the vertical axis. (From WAKEFIELD, E. G. and MAYO, C. W. Intestinal obstruction produced by mesenteric bands, in association with failure of intestinal rotation. *Arch. Surg.*, 33: 47-67, 1936.)

The symptoms are those of acute obstruction and surgical treatment should be instituted at once. Great care should be taken to avoid injury to the superior mesenteric vessels, which may course near the edge of the hernial ring and may be severed if an attempt is made to enlarge the ring to facilitate withdrawal of the bowel. Resection of a gangrenous segment of intestine may be necessary.

CONGENITAL ATRESIA OF THE INTESTINE

This uncommon congenital malformation occurs in two forms. The less common is a veil or diaphragm which completely obstructs the lumen. The more common consists of a thin threadlike remnant of intestine connecting the distended proxi-

mal bowel to the collapsed distal portion. This threadlike band connecting the two segments of bowel may be absent so that there is no vestigial connection between the proximal and distal segments or there may be several regions of atresia. Atresia as well as stenosis occurs as a result of an arrest of fetal development of the intestinal tract during the second or third month of fetal life. There is a well-defined intestinal lumen at the fifth week of fetal life. Following this there is a rapid growth and proliferation of the epithelium of the intestine so that the lumen becomes smaller and obliterated and the intestine passes through a so-called solid stage. Cystic spaces or vacuoles then appear and coalesce, re-establishing the continuity of the intestinal lumen. (Fig. 14.)

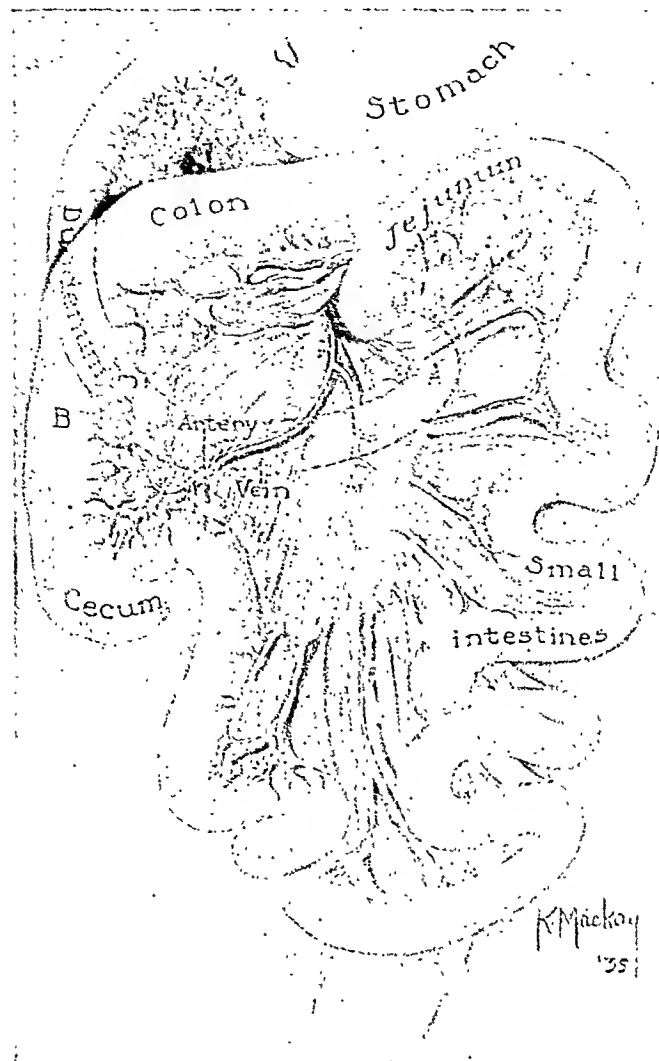


FIG. 11. Rotation completed. Duodenocolic isthmus now reversed (B-A). Duodenum is now retroperitoneal and the mesenteric artery is on the right side of the vein. (From WAKEFIELD, F. G. and MAYO, C. W. Intestinal obstruction produced by mesenteric bands, in association with failure of intestinal rotation. *Arch. Surg.*, 33: 47-67, 1936.)

Diagnosis. Intestinal atresia should be suspected if progressive vomiting begins shortly after birth. Bile almost always is contained in the vomitus, as atresia is rare above the entrance of the common duct into the duodenum.

Farber³ called attention to the fact that the amniotic fluid swallowed by the fetus contains epithelial cells from the vernix, which can be stained and identified from specimens of the meconium. In cases of atresia these cells, of course, are absent.

Roentgenologic examination reveals distended intestine or stomach above the lesion. Roentgenograms taken in the lateral

position as well as with the infant held head down aid in determining the level of the atresia. Barium studies should not be necessary. They are dangerous and should not be attempted.

Treatment. Cases of successful treatment are rare but the mortality rate is 100 per cent if atresia is untreated; therefore surgical intervention should be attempted.

Parental administration of fluids, transfusion of 5 cc. of blood per pound of weight and an inlying gastric tube should be used preoperatively. If possible a side-to-side anastomosis should be made between the enlarged proximal segment and the small

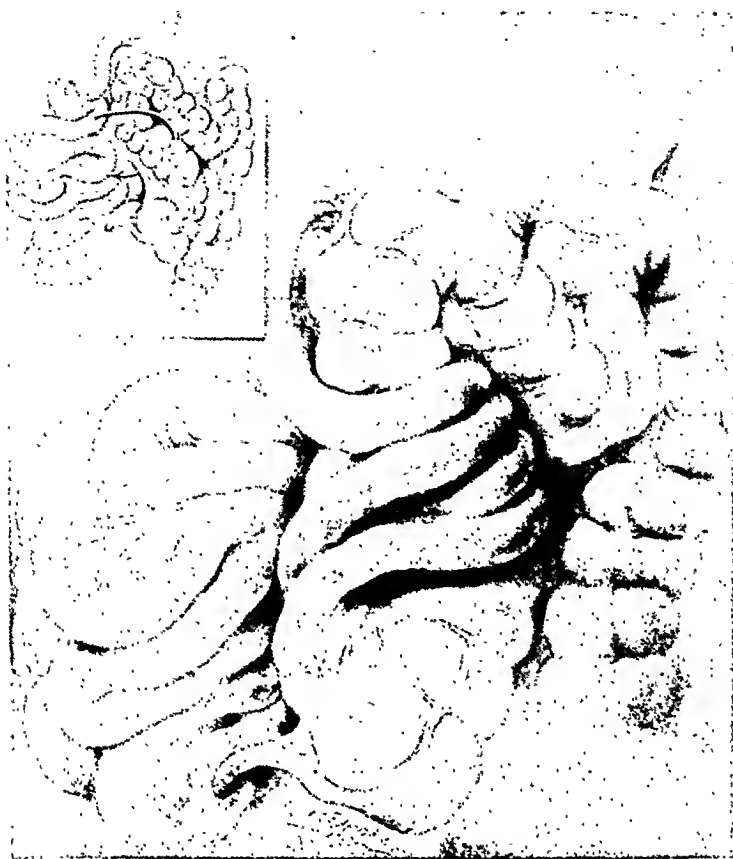


FIG. 12. Volvulus around a mobile right colon with malrotation of the midgut. Inset shows the colon on the left side of the abdomen and the intraperitoneal position of the duodenum. (From McKECHNIE, R. E., 11 and PRIESTLEY, J. T. Volvulus of small intestine, a report of thirty-seven cases. *Am. J. Surg.*, 34: 286-291, 1936.)

distal segment. This may be extremely difficult, but should be attempted even if the distal segment looks hopelessly small, as it soon acquires an adequate lumen. The distal segment may be distended with air as described by Webb and Wangenstein,¹⁸ or the anastomosis can be made over a small catheter which is removed just before the anastomosis is completed, as described by Ladd.⁹ This should be done with a single row of fine silk using a Connell stitch.

If the atresia is simply a diaphragm, it can be corrected by incising the bowel longitudinally, removing the membrane and suturing the bowel transversely, as described by Morton.¹⁴

CONGENITAL STENOSIS OF THE INTESTINE

Congenital stenosis in the small or large bowel is the result of the same type of arrest

of embryonal development as is found in atresia, but the obstruction is not complete. Thus the narrowing may be of any degree.

The symptoms and physical findings vary with the degree and location of the narrowing. In eleven of twenty-two cases cited by Ladd and Gross the lesion was in the duodenum. Persistent vomiting usually occurs within a few hours after birth with loss of weight or failure to gain. Bile may be absent if the narrowing is above the papilla of Vater. Epithelial cells may be found in the meconium if the obstruction is incomplete.

In some cases of mild stenosis there may be vague digestive symptoms over a period of years. In one of the twenty-two cases reported by Ladd and Gross the patient was five years of age and another patient was nine years of age. Figure 15 shows a

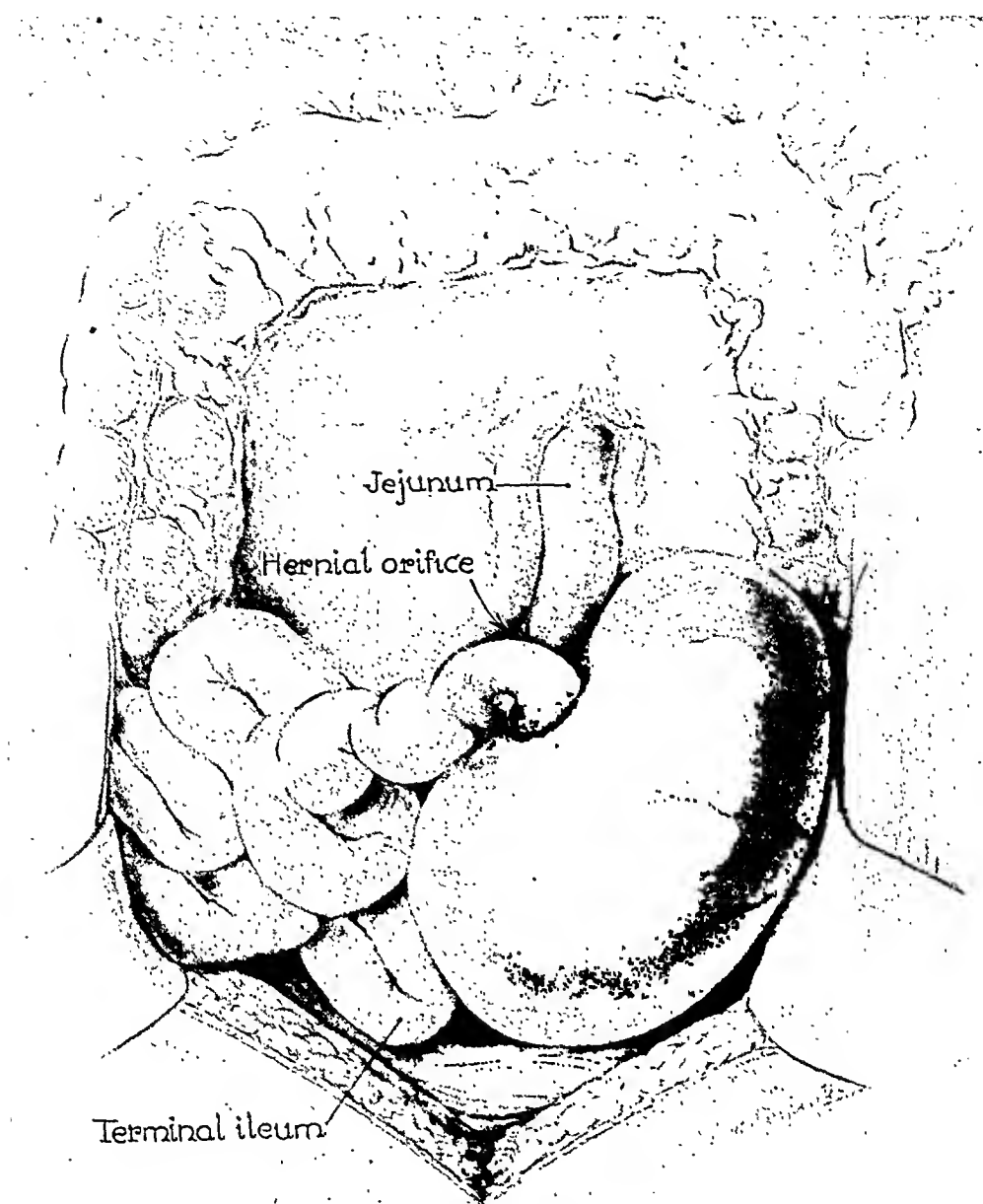


FIG. 13. Intra-abdominal hernia through a congenital defect in the mesentery of the terminal ileum.

congenital stenosis of the duodenum found at necropsy in a seventy-two year old man who had died of intestinal obstruction. He had had symptoms of intermittent obstruction since childhood. Barium studies may be helpful in questionable cases of longer duration, but barium must be given with caution.

Treatment. A short-circuiting primary anastomosis should be carried out. Dilatation of the stenosis with an instrument inserted into the lumen above or below the narrowing is unsatisfactory and should not be attempted. If the lesion is in the duo-

denum below the papilla of Vater side-to-side duodenojejunostomy should be done in preference to gastrojejunostomy.

CONGENITAL ATRESIA OF THE BILE DUCTS

Congenital atresia of the bile ducts is not an acute surgical condition but it will be reviewed briefly at this time. It was long thought that any attempt to repair congenital atresia of the bile ducts would be futile because of the associated cirrhosis and the involvement of the hepatic ducts in many cases. Following the work of

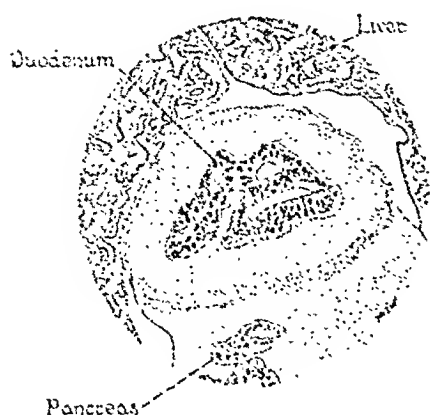


FIG. 14. Partial occlusion of the duodenum in a human embryo 18 mm. long. (From NAGEL, G. W. Unusual conditions in the duodenum and their significance (membranous obstruction of the lumen, diverticula and carcinoma). *Arch. Surg.*, 11: 529-549, 1925.)

atresia was amenable to surgical reconstruction. As in the intestine, the lumina of the bile ducts are patent early in fetal life, then become filled with epithelium, then later again become patent.

Jaundice is the main symptom. This is usually present at birth but it may not appear for two or three weeks. Erythroblastosis foetalis and syphilis should be ruled out. Occasionally there is some tendency to bleeding and for this reason vitamin K should be given in all cases.

Clinically, the infant appears healthy and well nourished. There may be some difficulty with the formula because of poor absorption of fat, so it is well to feed a low fat formula until the time of operation. If sterile bile is obtainable from an adult patient with a T tube drainage, it can be given to the infant in the formula. There is

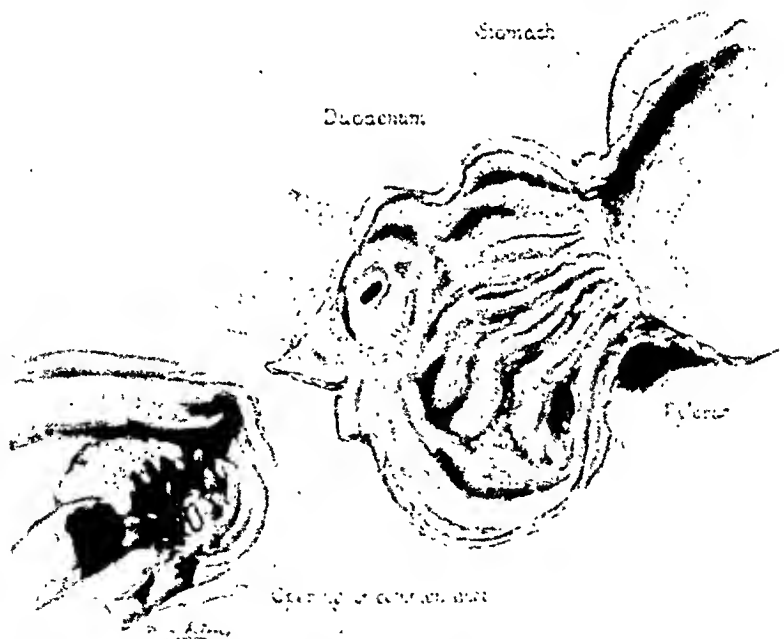


FIG. 15. Congenital duodenal stenosis in a man seventy-two years old. There had been symptoms of intermittent obstruction since childhood. (From NAGEL, G. W. Unusual conditions in the duodenum and their significance (membranous obstruction of the lumen, diverticula and carcinoma). *Arch. Surg.*, 11: 529-549, 1925.)

Holmes,⁴ who studied many examples of the various types of anomalies, it was realized that atresia of the bile ducts can be surgically corrected and is therefore worthy of exploration. In 37 per cent or fifteen of forty cases reported by Ladd¹⁷ the

no emergency about this condition and it is best to wait until the child is four or five weeks old before proceeding with surgical correction.

Atresia may exist in many forms from only fine fibrous cords representing the

extrabiliary ducts to atresia of only the distal portion of the common duct. If a portion of the common or hepatic duct is present, with or without a communication with the gallbladder, an attempt should be made to anastomose the duct with the duodenum with a single row of interrupted cotton sutures over a very small urethral catheter or vitallium tube. If a gallbladder is present and communicates with the common duct, it may be possible to mobilize the gallbladder from its bed and perform cholecystoduodenostomy. However, it is always better to make the anastomosis between the duodenum and the common or hepatic duct rather than the gallbladder even though the latter may be easier to do.

If a gallbladder is present it should first be opened to see if bile is present even though the ducts do not appear patent. Physiologic saline solution then can be injected and the ducts distended to determine their patency.

UMBILICAL EVENTRATION (OMPHALOCELE)

This congenital anomaly is due to the failure of part of the abdominal viscera to return to the abdominal cavity from the celomic cavity during the tenth week of fetal life. This failure is due to a disparity in size between the viscera and the abdominal cavity because of abnormally large intestines and liver, or retarded development of the abdominal wall.

The abdominal viscera at the site of the defect are covered only by a translucent layer of peritoneum and amniotic membrane. The umbilical cord is attached to the apex of the sac and the umbilical vein and arteries course over the membrane to enter the abdominal wall. The defect in the abdominal wall is usually 4 or 5 cm. in diameter, but may be considerably larger. (Fig. 16.) The membrane composing the sac loses its moist, pliable character after a day or two, becomes shriveled and dry and is easily ruptured.

Treatment. Regardless of how well an infant who has this anomaly may appear to be in the first few days of life, the infant



FIG. 16. Umbilical eventration.

will succumb to peritonitis if surgical repair is not instituted. As the membrane quickly dries out and there is no advantage in delay, operation should be performed in the first few hours after birth, before the intestinal tract becomes distended with food and gas.

The skin surrounding the defect is incised close to the membrane. The umbilical vein and arteries are carefully observed and ligated below the skin level. An attempt should be made to dissect out the muscle and fascial layers so that the rectus muscles can be brought to the midline over the peritoneum and posterior fascia. If possible, the anterior fascia should be plicated with interrupted sutures of silk or cotton. If the abdominal cavity is too small to permit primary closure in layers, the skin and subcutaneous fascia should be undermined and then approximated over the intestine. Secondary closure in layers then can be done about a week later.

DIAPHRAGMATIC HERNIA

The thoracic and abdominal cavities, which freely communicate with each other in early fetal life, are later separated by the septum transversum developing ventrally and joining a mesodermal proliferation developing dorsally. Striated muscle develops between the layer of peritoneum and pleura, forming the diaphragm. This development is complicated by openings left in the posterolateral parts of the diaphragm, which later become closed. Congenital diaphragmatic hernias occur most frequently in this posterolateral region, the site of the embryonic pleuroperitoneal canal. A few hernias occur at the esophageal hiatus and still fewer in the retrosternal region. (Fig. 17.) Hernias occurring from an arrest of development early in fetal life when there was free communication between the two

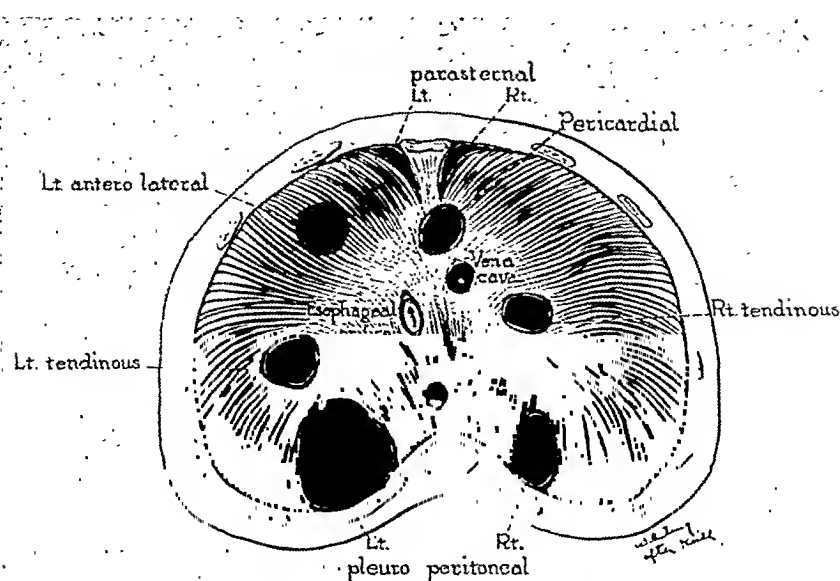


FIG. 17. Diaphragm seen from above, showing site of diaphragmatic hernias, both congenital and traumatic.

cavities will not have a sac. If the hernia has a sac, the arrest of development occurred after the peritoneal and pleural membrane separated the two cavities.

Diagnosis. Symptoms may be those of disturbed respiration, digestion or circulation. Dyspnea with or without cyanosis is common. It may be constant or may appear only when the infant is crying or feeding. The use of oxygen may be necessary. Examination of the thorax reveals decreased expansion on the affected side, a displaced apex beat, tympany or dullness depending on the underlying viscera and absent breath sounds. Vomiting may be the only symptom and occur with each attempt at feeding. The symptoms may be very mild and the diagnosis may not be made for several months. On the other hand, the symptoms may be those of circulatory failure and shock.

Roentgenologic examination should be done on any cyanotic or dyspneic infant as this usually immediately confirms the diagnosis. Barium studies should not be necessary and should not be used because of the danger of aspiration and subsequent pneumonia.

Treatment. As soon as the diagnosis is made, surgical repair should be instituted

as these infants usually become worse with waiting and the risk increases. During the first day or two the gastrointestinal tract is free from gas and distention and the procedure is technically easier than it is later.

Fluids and oxygen should be given preoperatively and postoperatively and gastric suction should be instituted if there has been delay in diagnosis. Also an indwelling rectal tube may facilitate gentle squeezing of gas from a distended colon.

Positive pressure anesthesia may be necessary, as a communication between the pleural cavities may exist at the anterior mediastinum as demonstrated by Ochsner and his associates,¹⁵ so that both lungs collapse when the pleural cavity is entered. Cyclopropane with its high oxygen content is desirable.

Phrenic crush immediately before the hernial repair is desirable as it facilitates the operation, and a high diaphragm affords more space in the abdominal cavity for the replaced viscera. In infants the abdominal approach should be used as there are no visceropleural adhesions and the viscera are easily pulled down from below. Reduction of the hernia by transthoracic approach would be impossible in many cases as the abdominal cavity is too small

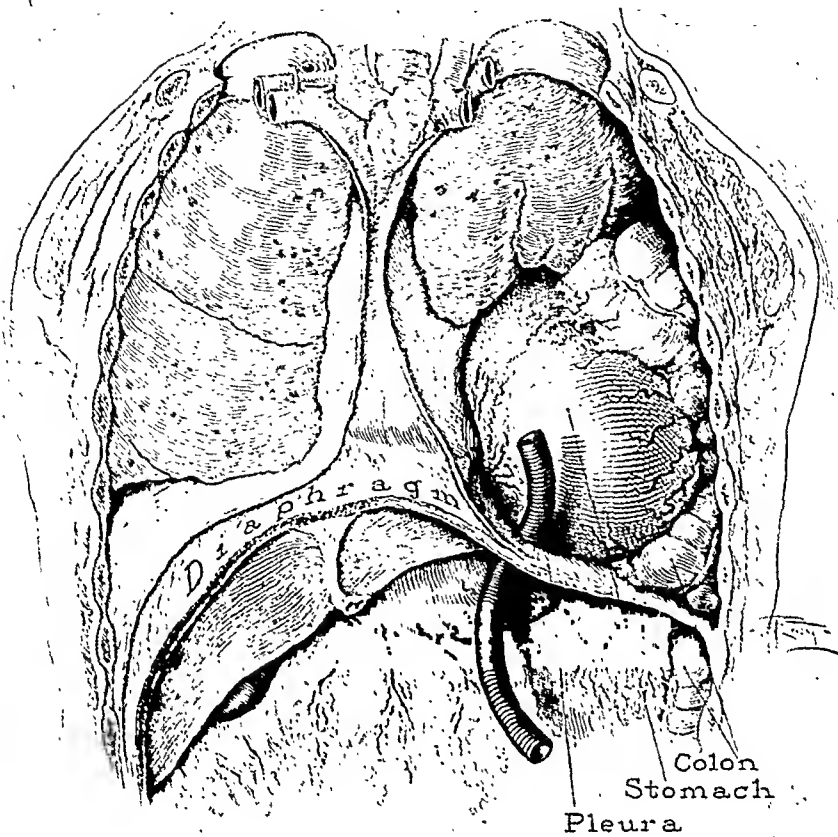


FIG. 18. Catheter inserted through the hernial ring so that air can enter the thorax and avoid development of vacuum as the viscera are withdrawn.

to hold all the viscera readily without causing respiratory or circulatory impairment.

Through a long left rectus incision, the muscle being retracted laterally to avoid injury to nerves, the viscera are withdrawn from the thorax onto the abdominal wall. This is done by first inserting a catheter through the hernial ring so that air can enter the thorax and avoid developing a vacuum as the viscera are withdrawn. (Fig. 18.) The viscera should be withdrawn systematically. In a left-sided hernia the stomach is withdrawn first, then the small intestine, the cecum, ascending colon and transverse colon and finally the spleen. In a right-sided hernia, the liver should not be withdrawn first even though this is the presenting organ. Such an attempt may damage the liver. The small intestine and then the colon should be withdrawn. The liver then can be brought down without difficulty.

The hernial ring should be closed with

interrupted sutures of silk or cotton after the edges of the ring have been denuded. The abdominal viscera then are replaced into the abdominal cavity and the incision is closed in layers. Frequently this is difficult or impossible because of a small, underdeveloped abdominal cavity. If this is present, the skin and subcutaneous fascia are undermined and then approximated over the intestines. Within five to seven days the abdominal cavity will have stretched and a secondary closure in layers can be done before the cutaneous sutures cut through. Primary closure may increase the intra-abdominal pressure and cause death by respiratory embarrassment or circulatory collapse. If there is any doubt, primary closure in layers should not be attempted.

When a true hernial sac is found, a small hole should be made in it after the contents have been removed so that air may enter the pleural cavity and the sac may be with-

drawn. It is then excised and the hernial ring is closed.

Esophageal hiatus hernias comprise only a small group and seldom are acute surgical conditions. As the symptoms usually are mild, the diagnosis is often made when the child is several months or years old. Surgical repair is indicated only when the symptoms are marked. The esophagus may be congenitally short and barium studies will be necessary to determine this and to plan the surgical approach. A transthoracic approach should be used if the esophagus is to be freed up in an attempt to place the stomach completely in the abdominal cavity. If the esophagus is too short, the hernial ring may be sutured to the stomach to prevent the entrance of the other abdominal viscera.

CONCLUSION

In conclusion, the surgeon should be ever mindful that it is the function of nature to maintain life in childhood, and it is his purpose to aid nature in her efforts. When nature does fail in her efforts, or surgical intervention proves fruitless the physician should attempt to obtain permission for postmortem examination as it is through such study that progress is made in the treatment of congenital lesions.

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PERITONITIS*

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PERITONITIS kills either by an overwhelming toxemia or by the nutritional and chemical changes incident to the associated small intestinal obstruction. If persistent leakage from a hollow viscus does not occur and if the toxemia and the obstruction can be controlled, rarely should there be a death from peritonitis.

TYPES OF PERITONITIS

The first consideration in the treatment of peritonitis is whether or not a surgical operation is indicated. If there is progressive leakage from a perforated viscus, the patient will not survive unless the leakage is stopped. Within a few hours any free perforation of the gastrointestinal tract will give conclusive evidence of its presence by the appearance of gas in the peritoneal cavity. An x-ray in the upright or lateral position will establish the presence of such a perforation, and unless the perforation appears to be sealed off and the peritonitis localized or unless the leakage can be stopped (as by gastric suction in the case of a perforated peptic ulcer), the indications for closure of the perforation are clear.

Perforations of an appendix must be considered in a different category from other perforations of the gastrointestinal tract because in appendicitis there is almost never a progressive leakage of the contents of the bowel. The lumen of the appendix is so small that it becomes obliterated by edema and prevents soilage. At the same time protective ileus keeps the cecum empty. For these reasons the considerations which apply to other hollow viscera may be disregarded in connection with appendicitis. The problem in this case is the control of a localized but spreading infec-

tion by organisms which are apt to be both virulent and resistant to antibiotics.

Aside from appendicitis and perforations of viscera the causes of spontaneous peritonitis are few. Salpingitis, complications of pregnancy, and streptococcal or pneumococcal peritonitis in children are now relatively rare causes of serious peritonitis and are almost always caused by organisms susceptible to chemotherapeutic and antibiotic agents. Until localization occurs operation is no more effective than it would be in the treatment of a lymphangitis. In this type of infection penicillin is so effective that the problem of treatment is solved.

It is apparent that peritonitis groups itself into three great classes: The first is due to perforations of the gastrointestinal tract with continued leakage as seen in perforation of a carcinoma of the colon; the second is due to the spread of a mixed infection from a primary source such as the appendix; and the third is due to the rapidly spreading invasion of the peritoneum by organisms of high virulence but of marked susceptibility to chemotherapeutic and antibiotic agents. In postoperative peritonitis any or all of these types may be represented.

Spreading peritonitis following operation is rarely caused by mere contamination of the peritoneum with the contents of a normal gastrointestinal tract provided good aseptic technique is used. In order to establish peritonitis it is usually necessary either to have continued leakage or to have contamination with the virulent organisms from a diseased viscus. Minimal contamination from an abscess around a carcinoma or from a colon affected by ulcerative colitis is much more apt to cause peritonitis than

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extensive fecal soiling from a normal bowel, provided that continued leakage does not occur.

In the case of postoperative peritonitis it is necessary to decide whether the trouble is due to leakage or the result of contamination. The problem is rendered more difficult because after operation the presence of free air in the peritoneal cavity is to be expected and does not help to establish the diagnosis of perforation. Since the diagnosis is difficult to establish, and since a leaking anastomosis is difficult to repair, secondary operations, except for drainage, rarely are undertaken. One must then rely on antibiotics, gastrointestinal decompression, and general supportive measures.

FACTOR OF OBSTRUCTION IN PERITONITIS

Before the development of the Miller-Abbott tube, intestinal obstruction was perhaps the most important contributory cause of death from peritonitis. The abdominal distention with loss of large quantities of fluid and electrolytes into and from the gastrointestinal tract, the disturbances in nutrition and protein metabolism and in acid base equilibrium all were potent factors in affecting the unfavorable outcome. Today many of these factors can be prevented or controlled, and obstruction should be a rare cause of death.

The two most important considerations in passing a Miller-Abbott or Harris tube are the foresightedness of the attending physician and the intelligence, industry and perseverance of the house officer or nurse to whom the technical details are delegated. The percentage of cases in which a house officer can pass a Miller-Abbott tube is as good an index as any of his conscientiousness and intelligence.

Perhaps more important than the details of passing the tube is the time at which the decision is made to pass the tube. If it is delayed until the patient is distended, too ill to cooperate, and until the ileus is so marked that the bowel has lost its tone, it may be exceedingly difficult to pass. Under these circumstances it is best to put

3 or 4 cc. of mercury in the balloon or use a Harris single lumen mercury weighted tube. The patient is then taken to fluoroscopy where the tube usually can be passed promptly under visual direction. Once it is through the duodenum difficulties rarely are encountered.

If the tube is passed before operation in those cases in which the development of peritonitis or intestinal obstruction is considered likely, the entire procedure is facilitated. Similarly it is much easier to introduce the intestinal tube immediately after an operation such as appendectomy for a ruptured appendix than it is to try to pass it two days later when peritonitis is well established. If intestinal intubation is instituted successfully, the major problem of peritonitis is under control.

FLUID AND ELECTROLYTE BALANCE

Although volumes have been written on the subject of fluid and electrolytes in surgical patients, the problem is, in the main, a very simple one. If the plasma proteins and the cardiac reserve are normal, there is little danger of giving enough fluid to cause pulmonary edema or cardiac decompensation. If the urinary output is 1,500 cc. or more a day and if the patient does not have a chronic nephritis, there is little danger of giving too much salt unless all the fluids are given in saline. If the patient has a deficiency of chlorides, it is desirable to correct this as soon as possible; because if this deficiency is not corrected, the lowered chlorides will cause the breakdown of body protein and result in the accumulation of non-protein nitrogen in the blood.

If the renal function is good and if adequate salt and carbohydrate is given the kidneys and lungs will maintain normal acid base equilibrium. In elderly patients, however, and in those with damaged kidneys the precautions urged by Coller¹ should be followed lest the administration of excessive amounts of salt cause retention of salt with consequent retention of water and disturbance in the acid base equilib-

rium. In such cases $\frac{1}{6}$ molar sodium lactate or plasma is preferable to salt.

As a working rule, the parenteral fluid intake should be 3,000 cc. of 5 per cent dextrose daily, 1,000 cc. of which should be in saline or $\frac{1}{6}$ molar sodium lactate. To this is added the amount of salt and the amount of fluid lost by gastrointestinal intubation.

until penicillin became available in unlimited amounts that progress was made in controlling peritonitis due to mixed infections.

The results of prolonged treatment of a series of fifty cases of proved peritonitis of appendiceal origin with 100,000 units of penicillin, every two hours for four days followed by smaller doses for several more

TABLE I*
FLUID BALANCE FORM FOR TWENTY-FOUR HOUR PERIOD

Intake Mouth		Intake Parenteral		Output (Suction, Vomitus, etc.) cc.	Output Urine cc.
Type	Amount cc.	Type	Amount cc.		
Water	500	5% glucose in saline	1000	1000	500
Water	500	5% glucose in water	1000	1000	500
Water	500	5% glucose in water	1000	500	500
		5% glucose in water	1000		
Total	1500	Total	4000	Total 2500	Total 1500
From Time 8:AM		Date 6/1/45		to Time 8:AM	Date 6/2/45

* Table reprinted from Hospital Care of the Surgical Patient by Crile and Shively, with permission of Charles C. Thomas.

As soon as the Miller-Abbott tube is passed there is no contraindication to the feeding of clear liquids by mouth. When the patient is taking fluid by mouth and has a tube in the stomach or intestinal tract, the problem of keeping an accurate record of the output from the tube and the oral intake arises. If the various types of oral and parenteral intakes and the urinary and suction outputs are not properly separated, the status of the fluid and salt balance cannot be evaluated. Table I affords a simple and effective means of recording these data in a form in which it can be visualized and calculated at a glance.

CONTROL OF THE INFECTION

There was no specific means of controlling pyogenic infections until the development of the sulfonamides and antibiotic agents. The sulfonamides were specific for infections caused by the hemolytic streptococcus or pneumococcus and helped to control the staphylococcus. But it was not

days has been reported in an earlier communication.² There was but one death in this series, and this did not occur as a direct result of peritonitis but from thrombosis of the mesenteric vessels. In all cases of spreading peritonitis the infection was controlled by penicillin. In all cases of localized peritonitis with or without formation of a mass, the infection was controlled and the mass eventually was absorbed. In no case was it necessary to drain an intra-abdominal abscess, and so far as is known there was no spontaneous drainage into the bowel.

The ability of *Escherichia coli* to destroy the activity of penicillin² could well account for the fact that massive doses of penicillin are required to control the gram-positive cocci when they are growing in a mixed infection associated with *Escherichia coli*. By giving enough penicillin over a long period of time eventually more penicillin is given than the *Escherichia coli* can destroy, and finally there is built up a

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sufficient concentration of active penicillin to inhibit the growth of the virulent cocci.

Although it can now be seen how it is possible for large doses of penicillin given over a long period of time to inhibit the gram-positive cocci, it is still difficult to explain why penicillin, in concentrations insufficient to inhibit *Escherichia coli*, eventually results in control of infections in which this organism predominates. The most reasonable explanation is that *Escherichia coli*, in pure culture, is not a pathogenic organism but is in reality a mere saprophyte. If this were the case one need not rely on antibiotics to control it, as the normal defense mechanisms of the body would be able to deal with it once the gram-positive cocci were inhibited. The absence of cellulitis around the infected wounds of patients receiving large doses of penicillin, the absence of tenderness of large intra-abdominal masses, the absence of friability of the tissues overlying these masses, the absence of paralytic ileus in the face of diffuse peritonitis when adequate doses of penicillin have been given for a few days, all of these findings and the frequent observation that the temperature may be normal and the patient may feel well in the presence of a large intra-abdominal mass, point to the fact that it is not *Escherichia coli* but the gram-positive cocci that are the chief offenders in peritonitis. If the

cocci are controlled, the peritonitis is controlled and the marvelous defensive and absorptive mechanism of the peritoneum is able to take care of the saprophytic or weakly pathogenic *Escherichia coli* infection.

In wounds, the defensive and absorptive action of the peritoneum is not available and, moreover, there is suture material, strangulated tissue, serum and blood in which *Escherichia coli* can grow. Even if it does not invade and cause cellulitis, a wound infection of low virulence is apt to develop. Instead of being absorbed, as it might be in the peritoneal cavity, eventually it drains. This explains the persistence of a normal expectancy of wound infections despite treatment with penicillin.

To check the *in vitro* resistance of mixed cultures to penicillin, a heavily seeded eighteen-hour agar slant of staphylococci Strain N.R. RL209 was washed with a six-hour broth culture of *Escherichia coli*. This was diluted to make a faintly turbid suspension and 0.01 cc. of this was used as the

After twenty-four hours' incubation at 37°C. smears were made of all tubes and stained by Gram's method. (Table II.) It is apparent that concentrations of penicillin of 0.039 unit per cc. inhibited the staphylococcus in pure culture, but that concentrations of 0.312 unit per cc.

TABLE II
COMPARISON OF CONCENTRATIONS OF PENICILLIN EFFECTIVE IN DESTROYING STAPHYLOCOCCI IN PURE CULTURE AS COMPARED WITH STAPHYLOCOCCI IN MIXED CULTURE WITH *ESCHERICHIA COLI*

Units of penicillin per cc. of medium.....	10	5	2.5	1.25	0.625	0.312	0.156	0.078	0.039	0.019	0.0097	0
Pure culture <i>Staphylococcus aureus</i>	—	—	—	—	—	—	—	—	—	—	—	—
Mixed culture <i>Staphylococcus aureus</i>	—	—	—	—	—	—	—	—	—	—	—	—
<i>Escherichia coli</i>	+++	+++	+++	+++	+++	+++	++	++	++	++	++	++

— = no growth
+ = growth

were required to inhibit the staphylococcus in the presence of *Escherichia coli*. The bacteriology studies were conducted by Mr. Alfred Reich of Cleveland Clinic.

The above figures indicate that approximately eight times as much penicillin is required to control staphylococci in mixed culture with *Escherichia coli* as when the staphylococcus is in pure culture. This figure corresponds quite accurately with the increased dosage required to control mixed infections as compared with infections caused by gram-positive cocci in pure culture.

Escherichia coli in pure culture usually is of low virulence, and if the virulent gram-positive cocci are controlled by penicillin the peritoneum is able to localize and eventually absorb infections due to the remaining *Escherichia coli*.

Since the sulfonamides are ineffective against the colon bacillus in the concentrations which they attain by the systemic route, since they are ineffective in the presence of pus, since they do nothing that penicillin does not do better, and finally since they may prove toxic, there is nothing to be gained by their use in conjunction with penicillin in the treatment of peritonitis.

The bacterial flora involved in peritonitis of appendiceal origin are much the same as are present following perforation of a hollow viscus or in postoperative peritonitis, and the response of all these types of peritonitis to adequate doses of penicillin is much the same. The patients do not appear so sick after the first day of treatment. The peritonitis does not appear to spread after the first twenty-four hours. By the fourth day if progressive leakage has not occurred, definite clinical improvement nearly always takes place. The abdomen loses its exquisite tenderness after the second day, and if the intestinal tube is functioning there is less distention.

The temperature begins to fall on the second day of treatment and in most cases reaches normal in a week. The pulse

rate remains slower than in uncontrolled peritonitis.

Pelvic or abdominal masses may appear during the course of treatment, but if 100,000 units of penicillin are given every two hours for from four to six days these usually resolve spontaneously and absorb without necessitating external drainage. Occasionally, a second course of treatment is required. A number of illustrative cases were presented in detail in a previous communication.²

ADJUNCTS TO TREATMENT

There are a number of helpful adjuncts to the treatment of peritonitis, most of which contribute to the patients' comfort but do little to alter the course of the disease. When the abdomen is distended, Fowler's position aids respiration but probably does little to localize the peritonitis. Hot stupes tend to relax the abdominal musculature and make the patient more comfortable but have not been proved to have any effect on the infection or intestinal motility. Drugs have little effect in controlling ileus resulting from peritonitis. Since an element of obstruction frequently is present, the benefits of a drug which increases peristalsis would be questionable even if such a drug were available.

Transfusion is of value when the patient is anemic and possibly when the serum proteins are low but otherwise does little for the patient with peritonitis. When edema develops it is usually a sign that too much salt has been given, and the most effective treatment is the withdrawal of salt and administration of water. If large amounts of blood or plasma are available, a transitory rise in serum proteins may be obtained, but both these and the amino acids have been disappointing in their inability to effect and maintain a significant rise in the serum proteins of a desperately ill patient.

MANAGEMENT OF INTRA-ABDOMINAL ABSCESSSES

If peritonitis is treated early enough, long enough, and with adequate doses

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of penicillin, the development of intra-abdominal masses which do not resolve after one or two courses of treatment is rare.

If a mass fails to resolve, there is rarely any hurry about surgical intervention. Penicillin usually controls the systemic reaction. A Miller-Abbott tube will obviate intestinal obstruction, and there is time to wait for the abscess to point so that it can be drained extraperitoneally. This is true of pelvic as well as abdominal abscesses, and here again it is best to wait until a fluctuant area can be felt by rectum or vagina. By this time the wall of the rectum is so friable that it is usually possible to penetrate it with the finger. In the case of the vagina it is more often necessary to make a small incision in the wall and insert a blunt instrument.

In some of the patients with peritonitis treated with penicillin, large pelvic masses developed and it appeared that they would point and drain. In two instances, fluctuant areas were palpable by rectal examination, but in neither did the wall of the bowel become sufficiently friable to allow introduction of the finger tip into the abscess. Both of these abscesses absorbed spontaneously without drainage. It was assumed that the penicillin controlled the cellulitis around the abscess to such an extent that

the tissues remained healthy and prevented the pus from pointing.

SUMMARY

1. Peritonitis due to a ruptured viscus must be recognized early and the perforation closed.
2. Peritonitis due to contamination by a pure culture of a virulent organism is usually easily controlled by antibiotics or chemotherapy given in standard dosage.
3. Peritonitis arising from a mixed infection does not respond well to treatment with sulfonamides, and unless there is continued leakage, operation has little to offer.
4. If the toxemia and spread of peritonitis is controlled by massive doses of penicillin, if the obstruction is relieved by intestinal intubation, and if the fluids and electrolytes of the body are replenished the mortality rate of peritonitis should be low.
5. It is essential to intubate the small intestine and to give massive doses of penicillin as soon as the presence of peritonitis is recognized.

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EARLY INDICATIONS OF ADHESIVE SMALL BOWEL OBSTRUCTION*

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THE early diagnosis of small bowel obstruction is related to the recognition of three essential clinical manifestations of the disorder and to the proper interpretation of the radiographic findings of an x-ray film of the abdomen.

The clinical manifestations are those associated with a particular type of pain, visible peristalsis and borborygmus, which may be called the "Big Three" of small bowel obstruction.

The pain in this condition is quite characteristic and different from any other type of abdominal pain. It is not localized to any one quadrant of the abdomen but is general in type. It is not constant but periodic in character, lasts for a minute or so, is cramp-like in character, increases in intensity and ends abruptly, only to recur in a short time. It is not associated with any tenderness or rigidity except to a slight degree when the obstruction is of a strangulated type or there are involved adhesive bands to the anterior parietal peritoneum. Even then the tenderness and rigidity in no way approaches that associated with an acute localized inflammatory process or specific colic. In fact, the colic of bowel obstruction is unlike that of any other kind of abdominal colic because of its diffuse nature, intervals of freedom from pain and absence to a large extent of localized tenderness and rigidity.

Associated with this pain there is seen, moving across the abdomen in early obstruction, an intestinal peristalsis that is synchronous with the paroxysm of pain. This likewise is periodic in character and stops with the cessation of pain. Often these peristaltic waves may be seen to move across the abdomen in succession at the height of the crisis of pain. Later in the

process, after distention has developed, the phenomenon may not be observed as intestinal distention lessens the violence of the contraction and the visibility of the peristaltic wave.

Correlated with the seizures of pain and the appearance of peristaltic waves there is heard upon listening to the abdomen a peculiar metallic sound which is synchronous with the pain and the visible peristalsis. The noise is unlike any other type of intra-abdominal sound, in that it is related in time, duration and termination, to the pain and peristalsis. The noise increases in intensity, has a metallic ring and ends abruptly in a crescendo of sound at the termination of the pain, only to recur with the next crisis of intestinal colic. This is well heard by auscultation with a stethoscope over the abdomen during a paroxysm of pain. It is known as borborygmus.

With a consciousness of the relationship of these symptoms and a recognition of their significance, a clinical diagnosis can be made of small bowel obstruction.

If there is a protruding mass on the surface of the abdomen significant of a strangulated bowel, the diagnosis is immediately confirmed; or if the abdomen shows evidence of one or more operative incisions, the suspicion of intestinal obstruction is further increased. These clinical manifestations associated with an increasing abdominal distention, without evidence of external strangulation or incisional scars upon the abdomen, likewise indicate bowel obstruction which immediately needs further confirmation.

The passage of gas, the movement of the bowels or adequate results obtained from an enema do not indicate that there is no

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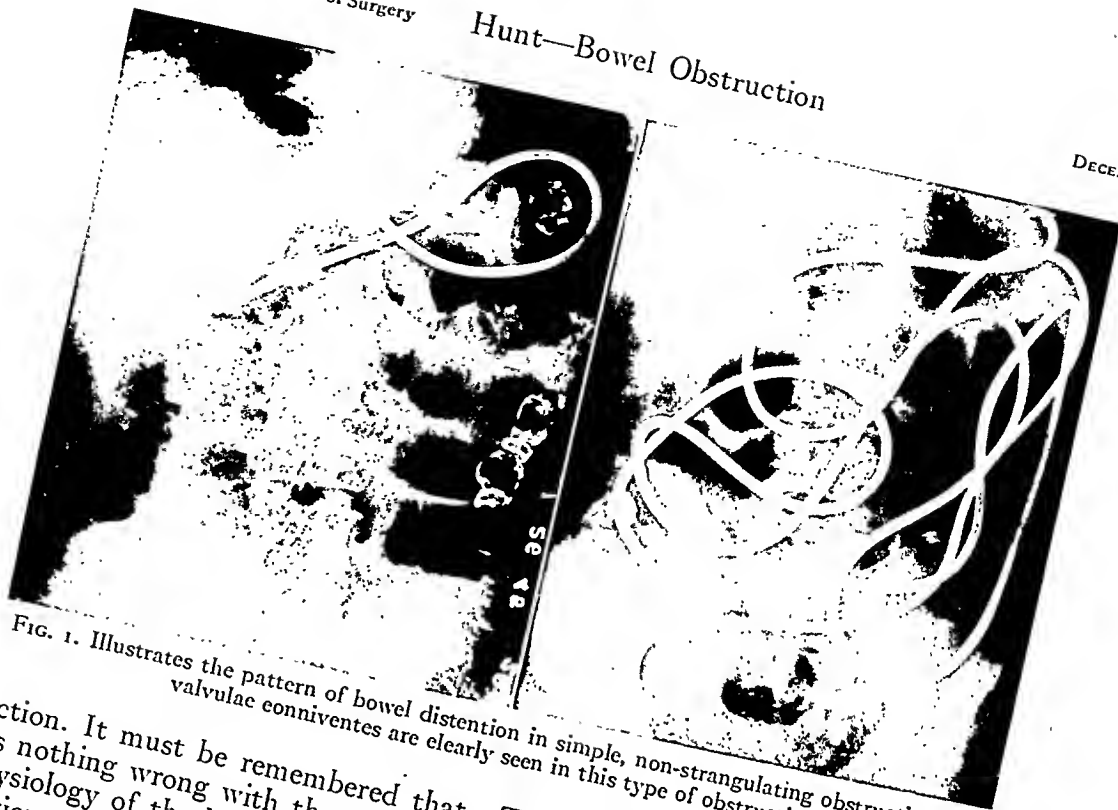


FIG. 1. Illustrates the pattern of bowel distention in simple, non-strangulating obstruction. The valvulae conniventes are clearly seen in this type of obstruction.

obstruction. It must be remembered that there is nothing wrong with the anatomy and physiology of the bowel distal to the obstruction and it can function adequately. This apparent function often gives a false feeling of security, only to find later a progressive obstruction with a possible peritonitis from a perforated strangulated gangrenous bowel. In fact, the distal bowel may empty itself from reflex action due to the presence of the obstruction.

This function of the bowel distal to the obstruction has been emphasized by Wangersteen and Goehl¹ and attention called to the disasters which may result if this is not fully recognized. Therefore, it can be said that the movement of the bowels, the passage of gas or adequate results from an enema by no means indicate the patency of the intestinal tract.

Regurgitant vomiting occurs early only in high intestinal obstruction. Since most small bowel obstructions are low, this type of vomiting does not occur until proximal bowel distention has become marked, abdominal distention is present and the clinical diagnosis is obvious. Early vomiting in low small bowel obstruction is reflex in character, as it is in colonic obstruction.

Therefore, it can be said that vomiting in the absence of abdominal distention may or may not be due to obstruction and further investigation is necessary for diagnosis.

The x-ray is the only means by which a positive diagnosis can be made of early small bowel obstruction. By this means a diagnosis can be made, the approximate site of the lesion determined and the probable nature of the obstruction ascertained. In interpreting an x-ray film of the abdomen, it must be remembered that gas is normally visible in the stomach and colon but not in the small bowel except in infants. Gas is present but is not detectable by a radiographic film because it is mixed or emulsified with the liquid contents of the small bowel and becomes discernible only on an x-ray film when the continuity of the bowel is obstructed. Therefore, gas observed in the small bowel by this method is significant of obstruction and it can be detected in a few hours after it has occurred.

The pattern which the gas in an obstructed bowel assumes determines the probable nature of the obstruction. If the obstruction is of a simple type due to an angulation of the bowel from an adhesive band or a band passing across the bowel,

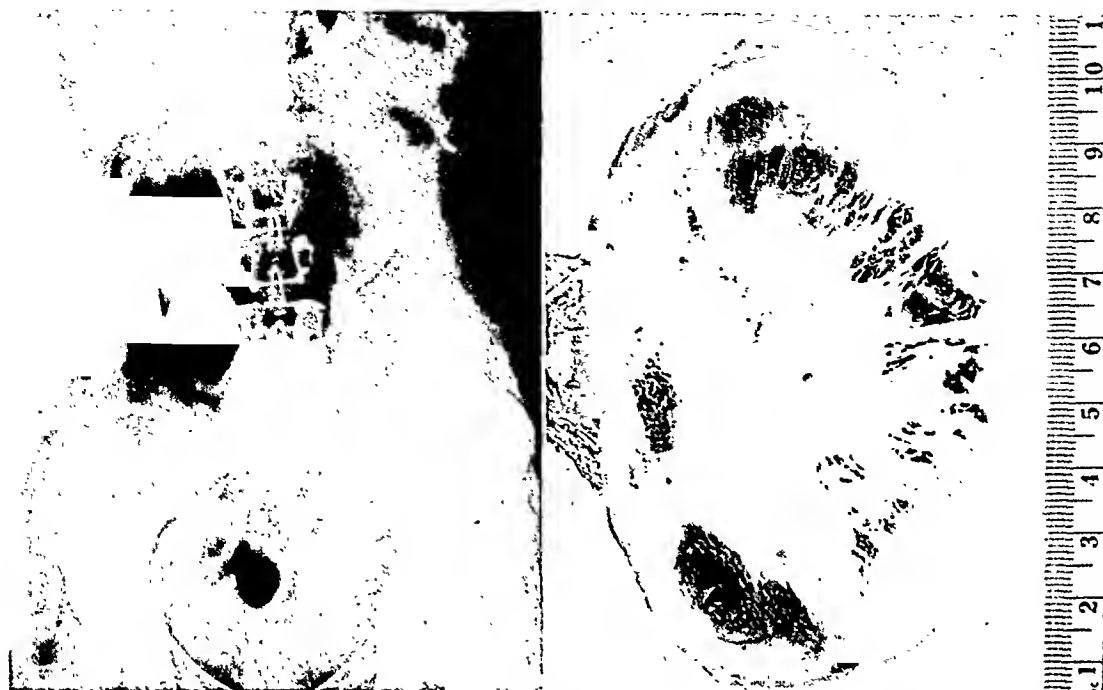


FIG. 2. Shows a distended loop of small bowel which does not assume any definite pattern of bowel distention, as is seen in Figure 1. The valvulae conniventes are not seen. The film is quite characteristic of strangulated obstruction. The resected specimen is shown.

the proximal portion becomes distended and in so doing gradually assumes a definite pattern in which the distended coils arrange themselves in a transverse position to the long axis of the body. The valvulae conniventes remain visible because the distended bowel is filled largely with gas and some liquid content and there is no extravasation of blood into the bowel, as is present in a strangulated obstruction.

This pattern becomes more pronounced with the advancement of the obstruction until ultimately a stairstep arrangement of the proximal distended bowel is observed. The thickness of the bowel wall indicates a relative degree of plastic exudate, fluid or peritonitis.

A strangulated obstruction, however, presents no such arrangement of the bowels in this transverse position. There is no definite pattern assumed by the distended coils of the bowel in this type of obstruction. The distended loops arrange themselves in whatever portion of the abdomen the obstruction occurs and no characteristic pattern is assumed and proximal distention above the site of strangulation is slow to develop, as empha-

sized by Wangenstein. In contrast to a simple non-strangulating obstruction, the valvulae conniventes are not seen or easily detected due to the extravasation of blood into the strangulated loop of bowel and into the free abdominal cavity.

It is important to differentiate, if possible, between a simple non-strangulated obstruction and a strangulated one. In the former the visibility of the bowel is not in danger and operation can be deferred until the patient can be physiologically prepared for operation by chemical and fluid rehabilitation and the distended bowel decompressed by intestinal intubation. In strangulated obstruction the blood supply is damaged, bowel gangrene and perforation are imminent and operation cannot be deferred. Physiological rehabilitation must be deferred until during and after surgery because of this impending danger.

Through careful correlation of the radiographic pattern of the distended bowel with the findings at surgical exploration we feel quite definitely that a competent radiologist can be of great assistance in determining the presence of small bowel obstruction, the approximate site of the lesion and the

probable nature of the disorder. We have found that by a careful study of the pattern of the gaseous distention the immediate urgency of the situation can be determined. We believe, always, in the immediate operation of all early small bowel obstructions, but there are many with marked fluid loss and great abdominal distention, who are not good subjects physiologically or anatomically for immediate surgery. If in these cases a careful study of the pattern of gaseous distention, as observed in a radiographic film, the lesion appears to be non-strangulating, physiological rehabilitation and intestinal intubation may be safely accomplished prior to surgery. The operation is then one of election and is much more satisfactorily and safely done, than when great distention is present and anatomical difficulties are great and hazardous.

Figure 1 demonstrates the value of the x-ray in evaluating the type of small bowel obstruction. It shows the transverse pattern of the bowel distention and the valvulae conniventes are clearly seen. The clinical manifestations and radiographic manifestations are those of simple obstruction with no evidence of vascular damage. The Miller-Abbott tube decompressed the distended intestines and aided materially in the surgical approach. Operation revealed a simple adhesive band obstructing the small bowel by constricting the lumen. Recovery was prompt after freeing the constricting adhesion.

Figure 2 shows an irregular type of small bowel distention that conforms to no pattern that is related to the long axis of the body and the valvulae conniventes are not seen. The clinical manifestation shows an uneven distention in the contour of the abdomen with slight localized tenderness and rigidity. Immediate operation disclosed a small bowel loop twisted upon itself by a band of adhesions attached to the bowel mesentery. The bowel was black and required resection. Recovery was unevent-

ful after resection and anastomosis. The x-ray was valuable in determining the nature of the obstruction and the need for immediate surgery.

We have found the correlation between the x-ray diagnosis by means of a flat film of the abdomen and the operative findings to be very accurate and have previously reported this relationship in August, 1944.²

We, therefore, emphasize the importance of competent radiological assistance in evaluating the nature of the obstruction of the small bowel and the need for immediate surgery. We know that in some instances of advanced simple obstruction surgery is more safely and effectively done after physiological rehabilitation and intestinal intubation by the Miller-Abbott tube has been satisfactorily employed.

SUMMARY

The clinical symptoms and signs of small bowel obstruction are characteristic and are unlike any type of intra-abdominal disease. The colic is specific in character and different from other forms of abdominal colic. The x-ray is most valuable in confirming the diagnosis of small bowel obstruction, in locating the site of the obstruction and in determining to a large extent the nature of the obstruction.

The function of the bowel distal to the obstruction is unimpaired and should adequate function take place it does not indicate the absence of obstruction.

The urgency of immediate surgery is emphasized in strangulated obstruction in contrast to the feasibility of delaying surgery in advanced simple obstruction until physiological measures and intubation procedures can be adequately employed.

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GUNSHOT

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GUNSHOT in warfare provides an abundance of casualties having every conceivable type of injury. Blast and burns, which may accompany highly explosive ordnance with metallic fragments of every known composition and size, complicate the medical care of these patients. The treatment of such wounded requires a fund of knowledge of the basic sciences with the exercise of immediate good judgment. In addition, there is needed the requisite technical skill of surgical procedures with an added ability to improvise.

No less can be said for the medical care of gunshot in civil practice except that the casualties are sporadic and fewer in number, and the missiles usually conform to specifications of size and composition. Blast and burns rarely complicate civilian gunshot, and there are usually available immediate adequate facilities and skill for their care.

We are reasonably certain that the removal of accessible bullets and foreign bodies was of paramount importance in all previous wars. This notion of mandatory removal persisted among many of us for a short time early in World War II, until the multiplicity of various sized fragments, widely scattered, made their removal utterly impossible. We soon adopted the principle of removing only those foreign bodies easily approached without producing permanent or extended disability, and in addition, those which caused interference with vital, visceral or skeletal functions.

Especially those foreign bodies lying within the walls of the torso or in the extremities, with few if any symptoms and not complicated by a hematoma, clothing and earth, were allowed to remain and to be removed at a much later time, and then only if deemed necessary. Possible accompanying anaerobic infections received

minor consideration because in this past war there was a well defined program of prophylaxis. Non-removal of innocuous metallic foreign bodies might well be adopted in civilian gunshot except for the legal aspects occasioned by the need for identification and ballistics. Since civilians are not prophylactically prepared against tetanus, gas gangrene and other infections in gunshot, the elements of drainage, inoculations, and chemotherapy must assume real importance.

Early in the war, foreign metallic bodies deeply embedded in the substance of such solid organs as the liver presented the problem of necessary removal. No former experience of anyone, nor available medical literature, could definitely provide us with the required information. Uncertainty prevailed as to whether the surrounding zone of necrosis seen in the roentgenograms might not lead to progressive parenchymal destruction or perhaps to the formation of an abscess or cystic cavity. Furthermore, in the surgical removal of deeply embedded bullets and small to moderate sized fragments from the liver, there existed the necessary trauma incident to localization and extraction with a fair possibility of not readily finding the missile. Finally, it was decided that such foreign bodies should be left in the liver and that this injured viscus would recover and encapsulate the object, without appreciable parenchymatous damage. Accordingly, several such patients harboring foreign bodies in the liver were closely observed clinically for several weeks with x-ray studies at intervals. The initial zone of surrounding necrosis disappeared after three or four weeks and the patients apparently suffered no ill effects. In order to verify our findings and opinion, we aseptically implanted previously removed metallic fragments into

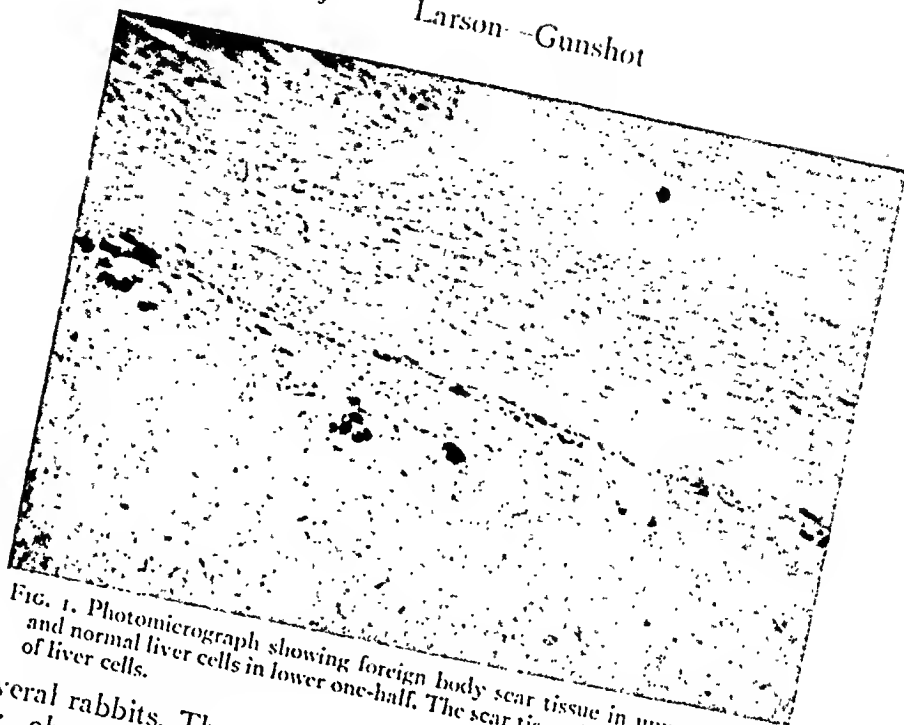


FIG. 1. Photomicrograph showing foreign body scar tissue in upper one-half, and normal liver cells in lower one-half. The scar tissue is encircling a strand of liver cells.

the liver of several rabbits. These animals were carefully observed clinically and studied roentgenologically at various times for a period of two years. They were then sacrificed, and at autopsy there was found in each instance a dense fibrous capsule about each foreign body, with no apparent damage to the parenchyma surrounding this fibrous capsule. (Figs. 1, 2 and 3.) Discussions with others having the same experiences led us to conclude that the liver entertains metallic fragments exceptionally well and in the manner as does other living elements supplied with reparative connective tissue.

Gunshot of the abdomen is cause for urgent and judicious care. Besides the shock, there is concealed trauma consisting usually of perforation and laceration of viscera and blood vessels which give rise to various degrees of hemorrhage and infection. The difficulty of knowing the extent of the injuries, the optimum time to explore, and where the incision is to be placed, arise immediately and must be considered while the patient is undergoing the treatment for shock.

These considerations become manifest after a close inspection of the position and character of trauma at the points of missile

entrance and exit, and the line of missile travel which indicates the viscera likely injured. From these observations, one learns whether the track is through and through or tangential, and in addition, deduction is made relative to the amount of trauma caused by the wobble of the bullet or fragment. In many instances, a retained missile located by an x-ray exposure at a distant area from the point of entrance complicates the assessment of the damage likely present. We recall one instance of a Japanese prisoner of war having a three-weeks' abdominal gunshot suddenly presenting the findings of a very acute appendicitis. An x-ray revealed a bullet to be retroperitoneal and under the cecum. A wholly different and possibly more successful surgical procedure was of course adopted.

The management of the severe shock usually present must have the first consideration. We found that $\frac{1}{2}$ to $\frac{1}{3}$ gr. of morphine administered intravenously, seemingly a forgotten procedure in civil practice, was found advantageous for immediate sedation. The utmost care was and must always be exercised to prevent dangerous morphinization, as varying doses of the drug may have been previously ad-

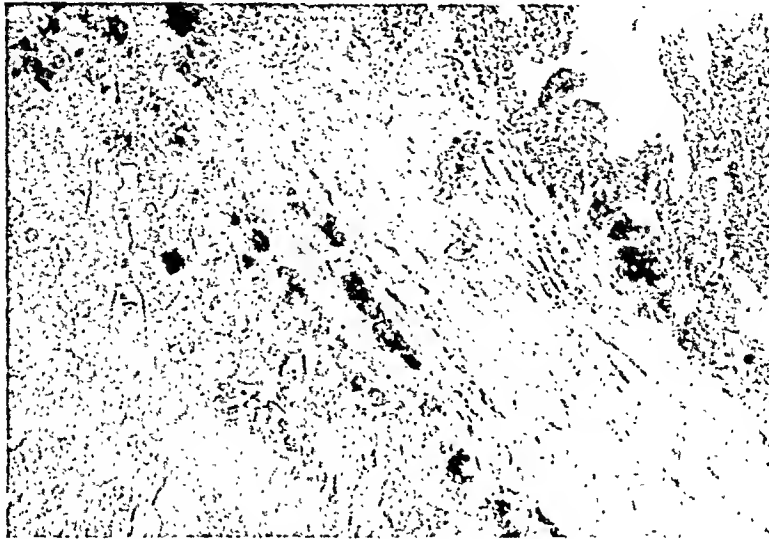


FIG. 2. A high power photomicrograph showing the sharply defined connective tissue enveloping a metallic fragment with surrounding healthy parenchymal liver cells.

ministered and unrecorded. Sufficient amounts of intravenous fluids, consisting of whole blood or plasma, with or without glucose-saline and serum albumin, if available, must be given immediately. We were often compelled to explore a patient still in shock, the relief of which required immediate and secure ligation of bleeding blood vessels or the placement of retaining sutures to stay hemorrhage of a solid organ. Serum albumin (Cohn), as previously mentioned, was found to be a very valuable agent, as it increases the blood volume by reverse osmosis in an amazing manner. On occasion when immediate venoclysis was necessary, we adopted the procedure of inserting the needle into the femoral vein in the groin, thus sparing the time necessary to expose surgically a collapsed vein. This allowed for immediate, rapid and copious intravenous therapy. We are certain that femoral vein puncture, another often forgotten procedure, can be utilized in civilian practice, especially in instances of severe injury complicated by extensive body burns.

In our opinion, the optimum time for surgical intervention, excepting those requiring immediate control of hemorrhage, averaged about two hours from the time of injury.

The incisions used and found most

appropriate were the right or left paramedian, so placed to afford ready access to the intra-abdominal injury. At times the entrance defect caused by missile was enlarged after a careful wound toilet with excision of the ragged wound edges. A second appropriately placed incision was often very valuable in facilitating further mobilization to expedite the surgery. On occasion assistants were delegated to make repairs wholly separate from the lesion immediately being cared for by the surgeon. Transverse incisions, although at times appropriate for good exposure of the upper abdominal injury, were rarely used because they result in weak scars and post-operative hernias, especially so if drainage must be instituted.

After exposure and cleansing of the peritoneal cavity, hemorrhage requires primary attention. Brisk bleeding arises usually from such solid organs as the liver, spleen, kidney and pancreas, and most often from lacerated mesenteric blood vessels. Following secure ligation of the blood vessels, the injured solid organs must be repaired. Large bleeding defects often require only vascular ties and sutures. Occasionally, a defect must be packed, using if possible some available omentum. Several instances required sponge packs deeply buried in the parenchyma of an



FIG. 3. A much higher power photomicrograph revealing the sharp outline between strands of healthy rabbit liver cells and the underlying dense fibrous foreign body capsule.

organ, such as the liver, with closure of the abdomen and removal at a later well selected time. Without exception these patients requiring such heroic measures did not survive. Fibrin foam¹ was found to be a valuable agent to assist in the stay of moderate parenchymatous hemorrhage. This most valuable agent should be made immediately available to all hospitals. Oxidized cellulose,^{2,3} used as absorbable dry sponge packs, is now available and should be found to be very efficient for staying major parenchymatous hemorrhage. The necessity for the dangerous removal of ordinary non-absorbable gauze packing can be eliminated since this oxidized cellulose is completely absorbed in a few days. We have had no experience with its use, but we can envision the usefulness it might have provided in many fatal instances.

Peritonitis due to perforations of the alimentary tract must be the next important consideration. Lacerations may require only simple suture, but often one or

more resections may be necessary. A careful examination is always made to prevent leaving behind a small unrecognized lethal puncture or laceration. When resections are necessary, we found that end-to-end anastomosis with a technic to prevent stenosis, using non-absorbable reinforcing sutures, was expeditious and rewarded us with excellent results. Following repair of the intra-abdominal injury of any type, we unhesitatingly irrigated the abdominal cavity, using copious quantities of warm saline solution with suction. We are convinced that this procedure is valuable because it removes the free blood, debris and contaminations, and in addition one obtains a more precise view of the repaired damage. In addition, 5 to 10 Gm. of sulfanilamide were usually sprinkled into the peritoneal cavity. On many occasions 100,000 units of penicillin were also instilled through a catheter which was withdrawn when the incision was repaired. The danger of peritoneal chemotherapy is that an occasional patient may suffer a severe reaction by being sensitive to such drugs. This was encountered several times, especially in sulfa sensitive individuals. This should have thoughtful consideration and be of great concern to surgeons in civil practice where one must deal with patients having had these agents used promiscuously for trivial ailments. After closure of the abdomen and with dependent and preferably suction drainage when necessary, we always added internal drainage by using a Miller-Abbott tube loaded with 6 cc. of metallic mercury and often passed by direct fluoroscopic vision. This manipulation under the fluoroscope assists in an accurate and rapid transit of the bulb to the pylorus, facilitating duodenal entrance in a short period of time. In several instances this tube was usually guided into the duodenum by manual manipulation when the operation was completed and the abdomen was still open.

A retroperitoneal hemorrhage or hematoma always requires careful investigation since the retroperitoneal organs, such as

the kidney or a fixed portion of the colon, may be seriously injured. A severely damaged kidney can usually be drained and left for a later and more considerate treatment. The same is not true relative to retroperitoneal colon perforations, for if left unrecognized and untreated, serious spreading retroperitoneal infections and abscess formations occur, enhanced, of course, by a good culture medium.

Other colon injuries localized by search and smell require skill and ingenuity in their surgical management. Simple suture of a colon defect, however well done, is rarely adequate. Injured sections are usually treated by exteriorization. When repaired *in situ*, a supplemental colostomy or other adequate vent for gas pressure and fecal stream becomes a most judicious procedure. We were able in a few instances to insert a large calibre mushroom retention catheter through colonic perforations. It was our experience that when this catheter was strung through omentum and out through a small stab wound and removed on the seventh to tenth day, the fistula closed promptly. Posterior retroperitoneal perforations were treated by catheter in the same manner and surprisingly without any extended invasive retroperitoneal inflammation. Perhaps efficient dependent and suction drainage with chemotherapy administered at the time of operation and during the postoperative period provided this safety. The same general principles for the postoperative care of patients with colon surgery were the same as were provided for those with injuries of the small bowel. Adequate but not excessive fluids with sufficient amounts of protein, carbohydrate and vitamins were carefully maintained.

Injuries to the spleen, when minor and not confined to the pedicle blood vessels, including small through-and-through bullet tracks, are usually not bleeding when exposed. We are certain that many spleens, having minor injuries which would heal spontaneously, are unnecessarily removed. In support of this statement, we had oc-

easion to observe at interval inspections, by means of the peritoneoscope, the rapid and complete healing of minor splenic lacerations.

Gunshot of the pancreas is a lesion that must be recognized. Such an injury requires good exposure and a very careful survey of position and extent. Carefully placed non-absorbable sutures that do not ligate or stenose the main ducts in the parenchyma, but control the hemorrhage, may promote survival of one having this dangerous lesion. Absorbable catgut sutures are less valuable because they are quickly digested. One patient having a pancreas almost severed by a crush against the spine survived under this management. Appropriate dependent or preferably suction drainage seems a prime necessity to prevent wide spread of the autolytic enzymes. The omentum was, in several instances, successfully utilized as a funnel embracing wicks which served efficiently as a barrier to the spread of pancreatic juice.

Thoraco-abdominal gunshot usually provide the most serious problem. Usually the liver, spleen, diaphragm and lung are injured. On most occasions operative repair was made through the original thoracic wound enlarged sufficiently to allow good vision and mobilization. The rent in the left diaphragm can be enlarged to perform splenectomy when necessary. After repair of the diaphragm and the thoracic incision with good postoperative management, including chemotherapy, these patients not too seriously injured survived. We can recall no instance of survival of such an injured man in whom the wobbling missile of any size traversed the liver from side to side with an explosive exit, and with injuries extensive enough to require parenchymal packing with gauze.

A skilled anesthetist is an important member of the surgical team. The repair of abdominal gunshot requires relaxation for adequate exposure. Spinal anesthesia, often continuous, is the anesthesia of choice. Occasionally, in prolonged procedures it must be supplemented with intra-

venous pentathol and quite often with eurare. This requires experience and judgment in knowing when and how to use these agents. Gas inhalants with positive and negative pressures must often be used, especially when the thorax is involved.

A statistical analysis is shown (Table 1) of the civilian gunshot in Los Angeles during the years 1940 to 1945, from the records of the Los Angeles General Hospital:

TABLE 1
GUNSHOT WOUNDS OF THE ABDOMEN

Year	Total Cases	Operated	Died	Post-operative Death
1940-41	29	21	10	6
1941-42	35	25	10	8
1942-43	36	25	12	8
1943-44	46	31	—	3
1944-45	31	21	10	—
	177	123 (69%)	49 (27%)	32 (26%)

GUNSHOT WOUNDS OF THE CHEST

Year	Total Cases	Operated	Died	Post-operative Death
1940-41	33	3	6	1
1941-42	43	4	3	2
1942-43	32	7	10	3
1943-44	30	1	2	—
1944-45	35	2	6	1
	173	17 (10%)	27 (15.6%)	7 (4%)

This tabulation of the civilian gunshot patients treated at the Los Angeles General Hospital, during the years 1940 to 1945 reveal a total of 350 patients. Abdominal and thoracic gunshot are about equal in number. The records reveal that 60 per cent of those with abdominal gunshot were subjected to operation with a 26 per cent mortality. There was a 10 per cent mortality on non-operative cases.

Of those with thoracic gunshot only about 10 per cent were subjected to operation, with a mortality of 41 per cent. The mortality of all thoracic gunshot was 15.6 per cent.

A study of the combination of both abdominal and thoracic gunshot in the same

individual, with surgical procedures and causes of death, cannot be within the scope of this paper. This chart merely serves to indicate roughly the statistics of civilian gunshot from a general hospital in a large city. A detailed study of all hospitalized gunshot in this city, with the details of the medical care, would be of great interest to me and perhaps to others who have recently cared for victims of gunshot in war.

SUMMARY

This paper is based on four years of active service as a surgeon in the past war. It seems appropriate to discuss and perhaps apply some of the principles of management of gunshot in war to civilian gunshot which will regrettably remain an occasional part of surgical practice. Active prophylaxis against anaerobic infection in our war gunshot is such a strict program that there remained the rare necessity of removal of most foreign bodies and even drainage of wounds. The same may not be true in civilian gunshot except when prophylaxis is immediate and efficient. Metallic foreign bodies are well tolerated in the liver as shown by clinical and experimental studies.

Survivors of thoracic gunshot are seldom subjected to surgical repair, while abdominal gunshot victims are seldom denied celiotomy. The relief of shock and stay of intra-abdominal hemorrhage with repair of lacerations is paramount. External and internal drainage with suction and an active chemotherapy seem important. Blood and plasma, and in addition, fluids containing an appropriate amount of proteins, carbohydrates and vitamins given intravenously are essential in the postoperative regimen.

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THE PRESENT STATUS OF THE PROBLEM OF REGIONAL ILEITIS*

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SINCE the classical paper on Regional Ileitis by Crohn, Ginzburg and Oppenheimer published almost fifteen years ago, a great amount of material has accumulated and certain definite opinions have been formed which deserve repeated emphasis. In talking to physicians from various parts of the country, it becomes apparent that, in spite of repeated publications on the subject, there is still considerable haziness concerning the clinical features of the disease and far more bewilderment as to what treatment constitutes the most desirable and effective method of therapy. It is the purpose of this short paper to relate our experiences with this disease in the hope that many of these debatable points may be clarified.

Our experience to date is concerned with the management of approximately 200 instances of this disease. Careful appraisal of the clinical histories of these patients has led to the grouping of symptoms into five main categories:

Acute Ileitis. There is usually no preceding history and the onset of the disease is fairly sudden, closely simulating that of acute appendicitis. In fact, in every instance of acute ileitis, operation was undertaken under the mistaken diagnosis of acute appendicitis. It is very doubtful if the differential diagnosis can be made pre-operatively, except in rare instances.

Symptoms of Enteritis. The triad of foul non-bloody diarrhea and cramps, loss of weight and anemia is fairly constant in this group. Fever may or may not be present, its occurrence depending a great deal on the extent of disease outside the bowel wall. It must be remembered that ileitis, so far of unknown etiology, starts as a mucosal ulceration, usually on the mesenteric side of the bowel, progresses

slowly, is accompanied by thickening of all layers of the ileum and is peculiarly characterized by perforation of these ulcers toward the mesentery with frequent formation of mesenteric abscesses. The latter is frequently the most common cause for the fever. As the inflammation progresses slowly, the diseased segment may become attached to the abdominal wall or to adjacent viscera, such as the cecum, small bowel, sigmoid, bladder, pelvic organs or ureter. Continuation of the infection may result in the spontaneous perforation of one of these abscesses or ileal ulcers through the abdominal wall or one of the hollow viscera. The *non-bloody* diarrhea is one of the main distinguishing clinical features from non-specific ulcerative colitis. This should be emphasized repeatedly. Another frequent clinical finding is the presence of perianal abscess or fistulas. These are due to crypt abscesses developing on the basis of the foul diarrhea, rather than to direct fistulous communication between the diseased ileum and the pelvic floor.

Symptoms of Obstruction. In a small group of patients, the disease remains confined to the ileum, progressing to a stage of great thickening of the bowel wall due to deposition of the products of inflammation, and marked diminution in the caliber of the lumen. Under such circumstances, symptoms of small bowel obstruction supervene, frequently clouding the true underlying process. I have seen five such cases and, in one, the symptoms of acute intestinal obstruction were evident on admission to the hospital. Only careful inquiry into the previous gastrointestinal history will lead to an accurate interpretation of the underlying pathological process.

Symptoms Caused by Involvement of Adjacent Viscera. As already indicated, the

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diseased segment of ileum may become adherent to a neighboring viscus and produce symptoms which might be interpreted as originating from primary disease of this viscus. Thus, fixation to the bladder will result in symptoms mainly of a urological character. The development of a spontaneous fistula into the bladder leads to the passage of gas, and possibly fecal material, per urethra. The occurrence of such symptoms in a young individual (and ileitis is by and large a disease of the young) should lead the physician to suspect ileitis as the underlying pathological process. I have seen four instances of enterovesical fistulas caused by regional ileitis. Fixation of the diseased loop in the female pelvis may lead to bizarre gynecological symptoms and physical signs. Finally, spontaneous perforation may occur into adherent cecum or sigmoid. These may be demonstrable on x-ray examination.

Presence of External Fecal Fistulas.

There is considerable misinterpretation of the exact pathogenesis of these fistulas. The belief seems to be widely held that they are due to the "blowing out" of the stump following appendectomy which is frequently performed under a mistaken diagnosis. However, the essential factor is the perforation of one of the ileal ulcers into the mesentery with the formation of an abscess and fixation of the abscess to the abdominal wall, followed either by operation or spontaneous opening externally on the abdominal wall, usually in the right lower quadrant. In my experience, the most common cause for a fecal fistula following appendectomy has been an underlying ileitis. These fistulas may be multiple. In one instance, twenty-six such fistulas were counted on the abdominal wall. Because of the origin of the fistulas from the diseased segment of bowel, the fistulous tract from the bowel to the skin surface may be long and tortuous. This point should be remembered when we discuss treatment.

The examination of a patient suspected of harboring regional ileitis may disclose interesting physical signs. Usually weight loss is obvious and anemia of mild degree is

present. One may palpate an ill-defined mass in the right lower quadrant which may become more clearly delineated on bimanual or rectal examination because of the well known tendency of the terminal ileum to lie downwards towards the pelvis. The presence of one or more fecal fistulas on the abdominal wall will aid in corroborating the clinical impression gained from the history. One must never fail to complete the examination by inspection of the anal region for fistulas and by a careful digital exploration of the rectum. I wish to emphasize the need for sigmoidoscopic examination to exclude the presence of ulcerative colitis.

What more can the physician do to establish definitely the diagnosis of ileitis? An x-ray examination of the colon by barium enema should be done. This will accomplish two purposes: firstly, it will exclude the presence of a concomitant ulcerative colitis; secondly, it may demonstrate the narrowed diseased ileum by passage of the barium through an incompetent ileocecal valve. Whether the disease is demonstrated by barium enema or not, it is important to supplement this examination by a regular gastrointestinal series by mouth. I wish to emphasize particularly the need for hourly or two hourly observations of the small bowel during this examination because it is important to demonstrate the presence or absence of diseased segments in the jejunum or upper ileum. The so-called "skip areas" are a characteristic feature of ileitis and they may be demonstrated in the x-ray films. However, it is more important for the surgeon to look for them at the operating table. The characteristic finding in ileitis is the so-called "string sign," described by Kantor. It is produced by the narrowing of the lumen in the diseased bowel because of the thickening of its wall. This typical x-ray finding is pathognomonic of regional ileitis.

On the basis of a large experience to date, we at Mount Sinai Hospital, are convinced that ileitis should be considered a surgical disease and treated as such. It is possible

that, with the disclosure of its exact cause, we may change this opinion; but at the present writing our best therapeutic results have followed surgical therapy. Occasionally, one sees a patient with a short history of mild diarrhea and fairly suggestive x-ray findings who maintains his weight, has no disabling symptoms and seems well in all other respects. Should such a patient be subjected to operation? We have advised against operation in such instances and have followed the patients for varying periods of time. The majority of these patients have remained relatively well and there has been no change in the radiographic findings. It seems to me that the indication for surgical intervention in such cases should rest with the severity of the symptoms.

I have been asked on many occasions what should be done when the surgeon finds an acute ileitis during the course of an operation for supposed acute appendicitis and the opinion has been expressed that, if an acute ileitis without perforation is found, nothing should be done. It is questionable if even appendectomy is advisable. The reason for this opinion is twofold: First, the patient usually is not prepared for an intestinal anastomosis, but what is more important, it is impossible to predict what the outcome in such cases will be. In the majority of such cases in our series, there have been no further symptoms and the patients have remained well, some for as long as fourteen years. In three instances, recurrence of symptoms necessitated operative intervention. We have been impressed with the tendency for spontaneous remission not only in the acute cases, but in many patients with extensive involvement of ileum and jejunum which are not amenable to surgical therapy. These remissions are of uncertain duration and frequency. However, I have not encountered a single instance of *chronic* distal ileitis in which remission has lasted for a number of years.

There has been considerable controversy in recent years as to what constitutes the most desirable operation in the treatment

of distal ileitis. One school is of the opinion that all such patients should be treated by ileocolic resection in one or two stages with complete excision of the diseased ileum and the enlarged mesenteric lymph nodes, on the theory that the disease is primarily one of the mesenteric lymph system with secondary changes in the bowel. On the basis of an experience with the largest individual series of cases ever reported and on the basis of a most careful and thorough follow-up study, we are of the opinion that resection is rarely necessary and that the lowest mortality and best follow-up results are obtained by the simpler operation of ileotransverse colostomy with exclusion of (complete division) the ileum well proximal to the upper limits of the diseased segment. We believe that the disease starts in the ileum, that the lymph node involvement is secondary, that, following the simple short circuiting operation, complete resection of the node involvement takes place as has been demonstrated repeatedly at secondary laparotomy. The removal of the lymph nodes is no guarantee against recurrence because proximal recurrence has occurred even after the widest type of resection. We are of the opinion that ileocolostomy with exclusion is the operation of choice because, in close to 100 patients so treated, there has been no mortality, because, in all but three instances, abdominal wall fecal fistulas have closed spontaneously, because in every instance of fistula between ileum and bladder, spontaneous healing has taken place, because large right lower quadrant inflammatory masses have gradually been absorbed and, what is very important, because our follow-up studies have shown the smallest percentage of recurrences. It is possible to perform an operation with a zero mortality and produce follow-up results which are infinitely superior to those following the more radical and hazardous procedures. These methods involve extensive dissections of fistulous tracts and the opening up of large areas of retroperitoneal cellular planes with an operative mortality of 13 per cent and a recurrence

rate almost double that following the simpler operation.

About two years ago Crohn and I reported the results of a careful study of 164 cases of ileitis. We were particularly interested in the comparative operative mortality and the follow-up studies. Sixty-five patients were treated by ileocolostomy with exclusion with a zero mortality. Fifty-five patients were subjected to a one-stage ileocolic resection with a mortality of 12 per cent. In nineteen instances of combined ileocolitis, a more complicated problem, the operative mortality was 10.5 per cent. The follow-up studies indicated that the ileocolostomy group showed a recurrence rate of 10.5 per cent, the one-stage ileocolic resection, a recurrence rate of 15.4 per cent and the two-stage resection group, a rate of 28.6 per cent. It seems to me that this analysis is conclusive proof of the superiority of the simpler operation of ileocolostomy with exclusion.

There are certain practical points in the operative management of ileitis that deserve emphasis:

It is an excellent plan to pass a Miller-Abbott tube preoperatively because it serves to decompress the bowel, thereby making for a smooth convalescence and aids in identification of various loops of bowel should extensive adhesions be encountered.

We recommend that the patient be placed in Trendelenburg position in order to aid in visualization of the various bowel segments.

Some years ago, I suggested that the abdomen be opened by a left rectus incision on the theory, that should a secondary resection become necessary at a later date, it could be carried out by a right sided approach in a field free of adhesions. The pathological lesion can be clearly visualized if the Trendelenburg position is used.

Under no circumstances should the surgeon attempt to separate the diseased bowel from viscera, such as bladder, cecum, sigmoid or small bowel, to which it has be-

come attached, because such a maneuver might result in the opening of sealed-over fistulous tracts. The whole purpose of the operation would thereby be defeated.

The entire small intestine must be carefully inspected for "skip" areas. The finding of diffuse disease in ileum and jejunum calls for no further operative manipulation inasmuch as jejunoileitis is non-surgical. It is important to divide the ileum well proximal to the most proximal "skip" lesion.

The operation of ileocolostomy in continuity should never be performed. The ileum must be divided always in order to effect a complete by-passing of the diseased ileum. In spite of the fact that we have repeatedly emphasized this feature as the most important part of the operation, we have seen an appreciable number of patients in recent years where division was not practiced and the surgeon formed the opinion that, because the symptoms were not relieved, the operation was a poor one. As a matter of fact, if the ileum is not transected, the symptoms are aggravated because a closed cesspool is created between the anastomosis and the strictured ileum with the production of additional toxic symptoms caused by absorption of noxious products in the bowel. In four patients so treated that I explored secondarily simple division of the ileum distal to the anastomosis resulted in an amazingly dramatic change. At the risk of appearing repetitious, I would repeatedly stress the importance of division of the ileum.

For the average surgeon, a side-to-side ileocolostomy is probably the safest type of anastomosis.

The various pathological, clinical and therapeutic features of ileitis have been stressed in this report because it is felt that a clear understanding of the whole problem is needed if optimum results are to be obtained. Particular emphasis has been placed on the need for thorough exploration of the entire small bowel and the use of an operative procedure which will give the lowest operative mortality and the largest percentage of desirable therapeutic results.

MESENTERIC LYMPHADENITIS

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IT is generally conceded that the mortality of appendicitis is the mortality of delay, often brought about by uncertainty as to diagnosis. I believe that another possible factor is the fact that some medical men are of the opinion that many patients with appendicitis will recover in two to three days without surgery and, therefore, feel justified in delay.

This erroneous idea is sometimes based on the fact that they regard every attack of acute right lower quadrant pain as being appendicitis and fail to realize that other conditions may produce similar symptoms. Thus when they see a patient with symptoms that suggest the possibility of an appendicitis and at operation see only a harmless appearing organ, they may think that the operation was unjustifiable and that these symptoms can be taken lightly more often than not.

While this idea is not very prevalent, I have seen evidence of the fact that it does exist and I believe it, too, is a factor in the mortality of appendicitis. If a broader understanding of the other conditions which may produce symptoms similar to those of appendicitis is developed, the consideration of these conditions will tend toward greater accuracy in diagnosis and should be of some aid in lowering the present mortality figure.

Thirty-five per cent of appendices removed under the diagnosis of appendicitis are said to be normal. This does not include those removed incidental to some other abdominal operation, such as pelvic disorders or gallbladder disease. A 35 per cent of error as quoted by Arkush and Kosky is enough to make a number of medical men feel justified in delays which may prove disastrous in some of the 65 per cent which are not normal. We must remember that the mortality of acute appendicitis is still too high and that increasing knowledge and awareness of this

condition by both doctors and public has not lowered it as much as we had hoped. Under these circumstances it is perfectly justifiable to remove an appendix whenever warning signals have been given, that made this diagnosis a probability.

There are some circumstances which make the conscientious medical man, or even the surgeon, who has had a recent appendiceal death hesitate to advise or to perform an appendectomy. One of these is a proper hesitancy to do abdominal surgery in the presence of appendiceal peritonitis. While all are not agreed upon this point, there are many high grade clinicians of wide experience, who practice conservative treatment at this time. Enough in fact to furnish adequate backing for anyone who prefers to follow expectant treatment in the presence of peritonitis.

At the other extreme, especially in children, is the condition noted when a child during the terminal phase of an upper respiratory infection develops abdominal pain and tenderness. The doctor who fears the dangerous complications of an appendicitis will have an appendectomy done, despite the sometimes greater danger of postoperative pulmonary complications and yet after taking this chance will find only a normal appendix. Two or three experiences of this sort will make him uncertain of his diagnostic acumen, and the next patient with somewhat similar symptoms, but this time with an inflamed appendix as the cause, may be allowed to go on to perforation.

Again, while most surgeons no longer accept the term of "chronic appendicitis," many children are seen who have periodic attacks of abdominal pain, associated with tenderness in the right lower quadrant. These subside quickly but often are found to recur after a mild cold, sore throat or slight bowel upset. If operation is decided

upon to relieve the recurring symptoms, an appendix will be removed which is normal grossly and microscopically, yet in a surprising number of cases the recurring symptoms disappear.

Of the several conditions which may be confused with appendicitis, the most common is that condition which has been termed "mesenteric lymphadenitis." While this condition has been referred to by some European writers, attention was called to it in this country by Dr. Leonard Freeman, of Denver, in an article presented to the Western Surgical Association in 1923. Since then, interest in it has grown, and a number of articles have been published, but it is still considered all too seldom in the diagnosing of acute abdominal conditions.

It first came to my attention in 1920 when Dr. C. U. Collins, of Peoria, Illinois, demonstrated it in a clinic he was holding and commented that when a person had symptoms of appendicitis but when at operation a normal appendix was found, the surgeon should carefully investigate the abdominal cavity until the real pathological condition was located; that in children enlarged mesenteric lymph nodes would often be found and that these were sufficient to account for the symptoms. He also stated the comforting fact that while the cause of the trouble was not certain, all the patients recovered from the operation and most of them from their symptoms.

The symptoms of mesenteric lymphadenitis have been recorded repeatedly for many years and several theories have been developed as to the cause. The consensus of opinion seems to be that the enlarged lymph nodes are due to absorption of toxins of bacteria. These bacteria have either caused the primary intestinal inflammatory reaction such as diarrhea, or to swallowed infected secretions in the course of an upper respiratory infection. The pain is presumably intestinal griping due to irritation from the same source.

The symptoms of mesenteric lymphadenitis

are quite variable but in general are as follows:

Pain is the most constant symptom. It is usually colicky in nature and comes on with paroxysms which increases in intensity. In the beginning it is mild and not as severe as the average appendicitis. In a few cases we have noted symptoms of real severity and a small number were so severe as to resemble a kidney colic or an intestinal obstruction in severity. The pain is due to intestinal spasm, and when severe may be accompanied by audible peristalsis. This is not true in the average case but only in the exceptional one of unusual severity.

Nausea and vomiting were more common in the older patients, nausea in 60 per cent and vomiting in 25 per cent. Temperatures varied from 99°F. to 103°F., but the average, even after two to three days, was from 99.6° to 100°F. The white blood count varied in proportion to the fever, averaging around 8,000 to 12,000, but occasionally being much higher. The differential count frequently shows an excess of lymphocytes but this is so variable that it can not be regarded as being diagnostic.

Rigidity is found occasionally but is usually not present. Incidentally, it may be present at one examination of the patient and absent later.

The chief method of differentiating between mesenteric lymphadenitis and acute appendicitis, in our experience, is in eliciting abdominal tenderness. In the average case of acute appendicitis, the tenderness is localized to the right lower quadrant and is usually at McBurney's point. Rebound tenderness is quite constant, and the further away from McBurney's point one presses the less the tenderness becomes.

In acute mesenteric lymphadenitis, however, the tenderness is quite generalized. There may be a tender area over McBurney's point, but there is often another corresponding tender area on the left side. One side is often as tender as the other and a moderate amount of tenderness is found in the upper abdomen also. Rebound tend-

erness is less likely to be noted and the general impression is one of suspected appendicitis but with symptoms being too mild to let the examiner feel certain that the appendix is really at fault.

Occasionally, a patient with a fever of 102°F . is found, but when contrasted with one of acute appendicitis with this much fever a marked difference is found in the lack of prostration. The patient with a fever of 101° or 102°F ., suffering from acute appendicitis looks and feels sick. The one with mesenteric lymphadenitis and this fever is not so hard hit.

The pathologic changes in the abdomen at operation vary according to the number, size and location of the lymph nodes involved. Sometimes they are enlarged throughout the length of the mesentery while in some they are limited to the ileocecal region. As a rule, individual nodes are seen scattered irregularly throughout the mesentery but sometimes they are so numerous as to appear confluent. They vary in size from that of a pea to that of a fifty cent piece although very few ever attain this size. We have never found suppuration or fluctuation. In patients with very severe symptoms some free fluid has been found in the peritoneum. At times the tissues about the nodes are injected and some nodes are adherent but they usually move freely between the layers of the mesentery. At times, particularly when a diarrhea has been present, even several days before the attack of abdominal pain, the terminal ileum has been quite injected. In these patients the lymph nodes were the most extensively involved of all.

In the course of the past twenty years this group has paid particular attention to this condition. We believe that it is a clinical entity and that given a reasonable amount of clinical experience it can be diagnosed in a high percentage of cases. In some seasons, especially in the spring months when respiratory infections are common, we have seen it run as high as 35 per cent in the patients in whom appendicitis was the original diagnosis.

Other than in providing academic interest in recognizing abdominal conditions, it has some very practical points of application. Whenever we see a child with an attack of acute abdominal pain, with tenderness most marked in the right lower quadrant with some fever and leucocytosis, we first and foremost consider the possibility of acute appendicitis. If the fever is slight and there is a relative lymphocytosis, and especially if the abdominal tenderness is somewhat generalized, we also give serious consideration to mesenteric lymphadenitis.

Our routine procedure is to try to arrive at a definite differentiation whenever possible, but we normally advise an immediate appendectomy. We have seen too many instances in which our preoperative diagnosis was mesenteric lymphadenitis but upon opening the abdomen a distended, acutely inflamed appendix was found. Whenever we open the abdomen with the diagnosis of mesenteric lymphadenitis and find a normal appendix, we are usually rewarded by the demonstration of numerous enlarged and often injected mesenteric lymph nodes. One consolation in this event is that many of these patients have given a history of repeated attacks of abdominal pain and we believe that we can be quite certain that not only will an initial recovery take place, but that the chronic abdominal symptoms or recurrent attacks of pain will no longer occur.

The exceptions to this statement are the children with large tonsils, cervical and inguinal adenopathy and a history of recurrent attacks of sore throat. In a few of these, but in only a few, the symptoms may recur until a tonsillectomy has been done and the gateway closed to further infection.

I believe that the most practical application of the diagnosis of mesenteric lymphadenitis exists in instances of upper respiratory infection with referred abdominal pain. In analyses of deaths from appendicitis it is not uncommon to find quoted instances in which children with

known respiratory infections have developed abdominal pain. An appendectomy has been done in spite of this existing pathological condition because of the fear of an appendicitis. Operation has revealed a normal appendix and autopsy has shown the pneumonia which was the real cause of death and which might not have developed had the abdomen been treated conservatively.

We in this group believe that when a child with upper respiratory infection develops abdominal pain it is well to consider the frequency with which mesenteric lymphadenitis complicates this condition. If this is done, the patient will not be so likely to be subjected to the additional risk of a laparotomy; for mesenteric lymphadenitis can be treated conservatively with perfect safety and in two to three days the patient will have recovered from the attack.

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SYMPTOMATIC ABDOMINAL EPILEPSY*

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IT is not a too infrequent experience for the surgeon or clinician to be confronted with a diagnostic dilemma and the decision whether to operate or not, when abdominal pain is the presenting symptom. In the majority of cases the symptom of abdominal pain is surrounded by other signs and symptoms with a recognizable sequence of events and an overall pattern which permit of the anatomic, etiologic and pathologic diagnosis. When these are partly wanting special laboratory or diagnostic procedures may be utilized to definitely establish the presence of intra-abdominal organic disease in its many forms. On the other hand many surgeons have felt the warm flush of embarrassment when faced with the realization of their diagnostic fallibility or impotence in certain cases, after removing an innocuous appendix or retreating empty-handed after an exploratory laparotomy. This situation usually arises in those cases in which abdominal pain has been a chronic symptom and which has eluded correct diagnosis after employing the numerous generally accepted diagnostic methods and which has not yielded to varied attempts at treatment. In this percentile small group which, however, is numerically large enough to justify and indeed require careful analysis before resorting to surgery or other ineffectual measures, there is to be considered the disorder known as symptomatic abdominal epilepsy.¹

The true clinician will not make this diagnosis by exclusion but will require some criteria which are at least sufficiently clear to draw this condition into the pale of a recognizable entity. However, thus far, the consideration of symptomatic abdominal epilepsy, as a cause of abdominal pain has

been a last resort measure, the usual story being one of prolonged, assiduous, extensive, futile studies of the gastrointestinal tract, other abdominal viscera, thoracic viscera, genitourinary tract, vertebrae, and spinal cord and its roots, with the final chapter often ending with a fruitless abdominal exploration or the patient being stigmatized with the appellation of psychoneurotic.

Definition. Symptomatic abdominal epilepsy is a disorder characterized by bouts of paroxysmal abdominal pain, the latter being due to hypermotility of the bowel, provoked by abnormal discharges of certain neurones in the vicinity of biochemically or structurally altered cerebral tissue, presumably situated in the premotor, and postmotor cerebral cortex and/or the diencephalon. The attack of abdominal pain at times may be single and prolonged only when the symptom occurs as the result of a vascular ictus, or a neoplasm involving the frontal and parietal lobe and/or diencephalon.

Experimental and Clinical Data. The most definitive recent work relating abnormal gastrointestinal motility with cortical influence has been by Fulton and his co-workers,² Spiegel, Weston and Oppenheimer,³ Penfield and Gage,⁴ and Penfield and Erickson.⁵ In a brilliant series of animal experiments Fulton et al.² demonstrated that stimulation of area six (Brodmann) produced disturbances in gastrointestinal motility; ablation of the frontal lobes followed by hypermotility of the stomach and pyloric spasm enduring several days; and acute intussusception with fatal obstruction following bilateral ablation of the frontal lobes or its parts. These investigators were of the opinion that areas three

* From the services of the Jewish and Doctors Hospitals, Philadelphia, Pa. The histopathologic sections are from the John L. Eckel Laboratory of Neuropathology and were used through the courtesy of Dr. N. W. Winkelman.

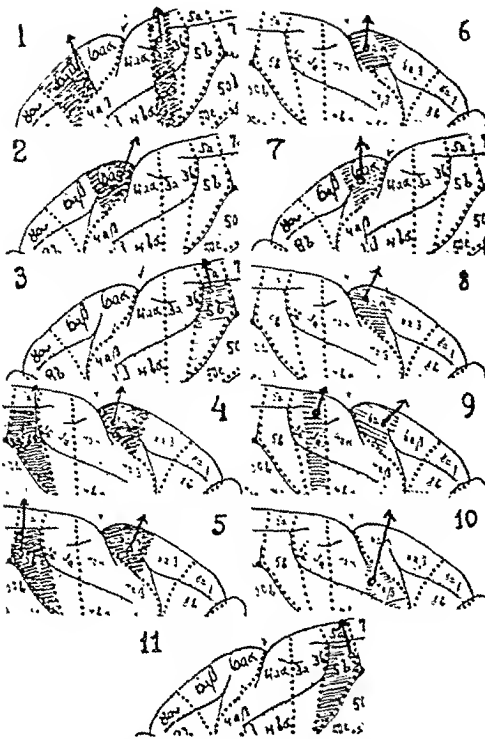


FIG. 1. Location of foci from which the gastrointestinal system could be influenced. The foci are indicated by the cruciate sulcus by (cortical areas in the dog according to Kelmpin) (SPIEGEL, E. A., WESTON, K. and OPPENHEIMER, M. J. Courtesy of authors and J. *Neuropath. & Exper. Neurol.*)

and five of Brodmann were also concerned with gastrointestinal activity. Penfield and Gage⁴ stimulated electrically area five-a of the exposed brain of a patient, resulting in pain in the lower right quadrant of the abdomen which then was followed by a convulsive seizure. It was shown quite clearly in experiments on dogs by Spiegel, Weston and Oppenheimer² that the whole gastrointestinal tract could be influenced by stimulation of areas six, five and three. (Fig. 1.) They observed that stimulation of these areas may produce effects in all parts of the gastrointestinal tract synergically, increase of activity in one part may be associated with inhibition in other parts of the gastrointestinal system, or occasionally only a limited part of the bowel may be influenced.

The exact manner in which the diencephalon exerts its influence upon gastrointestinal motility is not entirely

understood. However, Watts and Fulton⁶ have produced experimental diencephalic lesions resulting in disturbed gastrointestinal activity. Cushing⁷ called attention to the probable rôle played by the diencephalon in disturbances of gastrointestinal motility and the production of peptic ulcer following brain trauma when there was involvement of the diencephalon.

Clinically, it has been known for some time that abdominal distress or even pain may constitute part of the preconvulsive aura of epilepsy and Fulton⁵ has stated that this pain usually coincides with vigorous abnormal gastrointestinal movements. Abdominal pain likewise has been reported as a symptom of gross cerebral disease. Wechsler⁹ has seen patients who were treated for some time and even operated upon for abdominal syndromes in whom abdominal pain was the symptom of a cerebral lesion. This pain can closely resemble the pain of gallbladder disease, gastric or duodenal ulcer, appendicitis or renal colic. Winkelman¹⁰ cited the case of a forty-five year old man who experienced intense abdominal pain as the initial symptom of a cerebral hemorrhage involving the frontoparietal areas. Abdominal pain in children frequently is an extremely difficult symptom to evaluate and recent studies by Klingman, Langford, Greeley and Hoefer,¹¹ and also by Lambert¹² have shown that formerly unexplained attacks of paroxysmal abdominal pain were a manifestation of the convulsive state. These workers were able to observe cerebral dysrhythmias in the electroencephalographic studies of their patients of the petit-mal and psychomotor equivalent varieties. Some of the children had associated symptoms of the convulsive state accompanying the paroxysmal abdominal pain.

In his very succinct and inclusive way, Hughlings Jackson said, "Epilepsy is the name for occasional, sudden, excessive, rapid and local discharge of gray matter."¹³ The expression of subjective or objective manifestations in the patient depends upon the locus of discharge. The commonly seen

motor Jacksonian convulsive seizure is often the symptomatic expression of a focal discharge in the motor area resulting from a discrete lesion, be it tumor, traumatic scar or other morphologic structural change. Should the lesion which initiates paroxysmal cerebral dysrhythmias be situated elsewhere in the brain, the symptoms would reflect the function of that part. It is, therefore, not an exercise of the imagination to conceive of focal lesions involving any one or all of areas six, five and three of the cerebral cortex or of the diencephalon which could produce, under appropriate conditions, abnormal discharges which would lead to disturbed gastrointestinal activity and consequent abdominal pain. These lesions could very well be of varying magnitude in size and of different histopathologic appearance.

In order to demonstrate the relationship existing between abdominal pain as a symptomatic expression of cerebral disease, the representative cases cited here will take into account those lesions which are gross and demonstrable, those in which a history of pre-existing disease or trauma would conceivably lead to a cortical lesion, and finally those in which there may be some question as to a specific causal factor producing a focal lesion with subsequent abnormal cortical discharges.

CASE 1. (Brain tumor—single focal lesion). H. P., was a sixty-three year old male whose chief complaints consisted of periodic attacks of severe epigastric pain and headache. He was first seen by me on April 21, 1946. For six to eight weeks prior to this he had complained of recurrent attacks of intense abdominal pain which led to complete x-ray study of the gastrointestinal tract by his attending physician. These proved negative. Loss of weight directed attention to possible malignancy, but none could be unearthed. About five weeks prior to examination he developed headaches situated over the frontal and suboccipital regions. Shortly thereafter a pronounced mental change occurred which was interpreted as a depression and the diagnosis of involutional depression was made by several physicians. He was to be transferred to a mental institution

to receive electroshock treatment when I was requested to see him.

On the day of examination he showed the following; mental hebetude, spontaneous, brief outbursts of unprovoked crying, mild left hemiparesis, suggestive hesitancy of the left leg in walking, wavering of the outstretched left hand, increase of the deep tendon reflexes of the left arm and leg as compared with the right side, characteristic grasp reflex in the left hand, suggestive Babinski phenomenon on the left, mild weakness of the left corner of the mouth and bilateral choked discs. When questioned as to the most distressing symptom he pointed to the "pit of his stomach." Spinal puncture revealed a pressure of 320 mm. C.S.F. X-ray examination of the skull was negative. A diagnosis of tumor of the right frontal lobe lying rostral to the motor gyrus impinging on area six was made. In view of the rapid progress of symptoms it was believed that the lesion probably was a glioma.

On April 30, 1946, a craniotomy was performed by Dr. Robert A. Groff at the Graduate Hospital of the University of Pennsylvania. Directly beneath area six at a depth of about 2 to 2½ cm. below the pial surface a discrete spherical tumor mass was encountered and removed. (Fig. 2.) The overlying and surrounding brain tissue was soft and appeared swollen. The tumor mass was firm, showed a smooth pseudocapsule and measured 2.1 cm. in diameter. Histologic study revealed the cytologic appearance of a metastatic malignant growth with some characteristics resembling spongioblastoma multiforme. The surrounding white matter and overlying cortex showed a pronounced glial proliferation. Postoperatively the symptoms of headache and abdominal pain disappeared. The pronounced forced grasping quickly diminished within three days after operation.

This case illustrates the occurrence of paroxysmal abdominal pain which had been interpreted as a form of intrinsic disease of the gastrointestinal tract. The early phase of this patient's symptomatology was exclusively gastrointestinal. The subsequent headache apparently had been dismissed in its significance and later even the gastrointestinal symptoms, after the x-ray findings had been negative, were likewise dismissed as a somatic complaint



FIG. 2. Sketch of right side of brain indicating the position of the tumor found in Case 1, solid circles motor area 4; open circles pre-motor area 6.

part of the picture of an involutional depression. The mental status of the patient should have been considered, as it was later, as a symptom of organic brain involvement. Had this been done and the headache properly evaluated, the symptom of abdominal pain would have completed the pattern establishing the diagnosis of a brain tumor involving the right frontal lobe. The abdominal pain, therefore, was the symptomatic expression of abnormal discharges arising in the premotor area secondary to the "irritation" or stimulation by a localized space-taking lesion subjacent to area six.

CASE II.¹⁴ (Tuberous sclerosis—disseminated lesions in the brain.) A. D., female, aged three years, was admitted to the Jewish Hospital with a diagnosis of rickets. At the age of five months she had recurrent attacks of abdominal pain which caused her to "double-up" and cry out. These seizures were of relatively short duration and occurred both during the day and at night. The attacks of abdominal pain were followed by excessive urination and sleep. Studies of the gastrointestinal tract revealed nothing abnormal. The attacks of abdominal pain endured until the patient was eleven months of age. A tentative diagnosis of intestinal tetany was made and the patient treated on this basis. Subsequently the child failed to develop in a normal manner and was unable to talk, had no control of bowel or bladder function and showed abnormal behavior with periodic, abrupt attacks of crying, screaming and thrashing about. These attacks

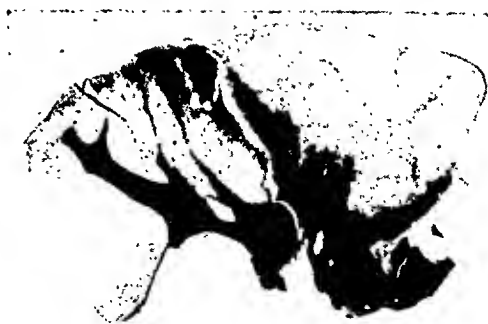


FIG. 3. Section of brain showing disseminated lesions of tuberous sclerosis. (Weil stain $\times 2$.)

were unpredictable and occurred at irregular intervals during the day. When examined neurologically the positive findings were pronounced mental deficiency, partial atrophy of both optic discs, defective hearing, nevus multiplex of Bourneville (sebaceous adenoma of Pringle) over the nose and maxillary region. Complete laboratory studies consisting of x-ray examinations and chemical studies of the blood and spinal fluid proved negative. The paroxysmal nature of the abdominal pain from the age of five months to seventeen months was interpreted as an epileptoid manifestation since these were replaced by recurrent bouts of behavior disorder having the pattern of the convulsive state.¹⁵ The triad of mental deficiency, nevus multiplex of Bourneville and epileptic phenomena allowed the diagnosis of tuberous sclerosis.

The nodules of tuberous sclerosis are irregularly scattered throughout the brain and not only can they involve the motor area producing the usual epileptic motor seizures observed in tuberous sclerosis but they undoubtedly also involve premotor area six and the postcentral areas five and three. In the case cited here the lesions provoked abdominal pain as part of the total picture of an epileptic display. Figure 3 shows the irregular distribution of the lesions of tuberous sclerosis and how they implicate the cerebral cortex producing abnormal discharges from "irritated" cortical ganglion cells.

CASE III.¹⁶ (Cerebral trauma.) N. T., male, age eleven years, gave the history of having had three attacks of unconsciousness during the four years prior to examination on December

FIG. 4. (Case III). Electroencephalographic tracing prior to treatment. (Courtesy J. A. M. A.)

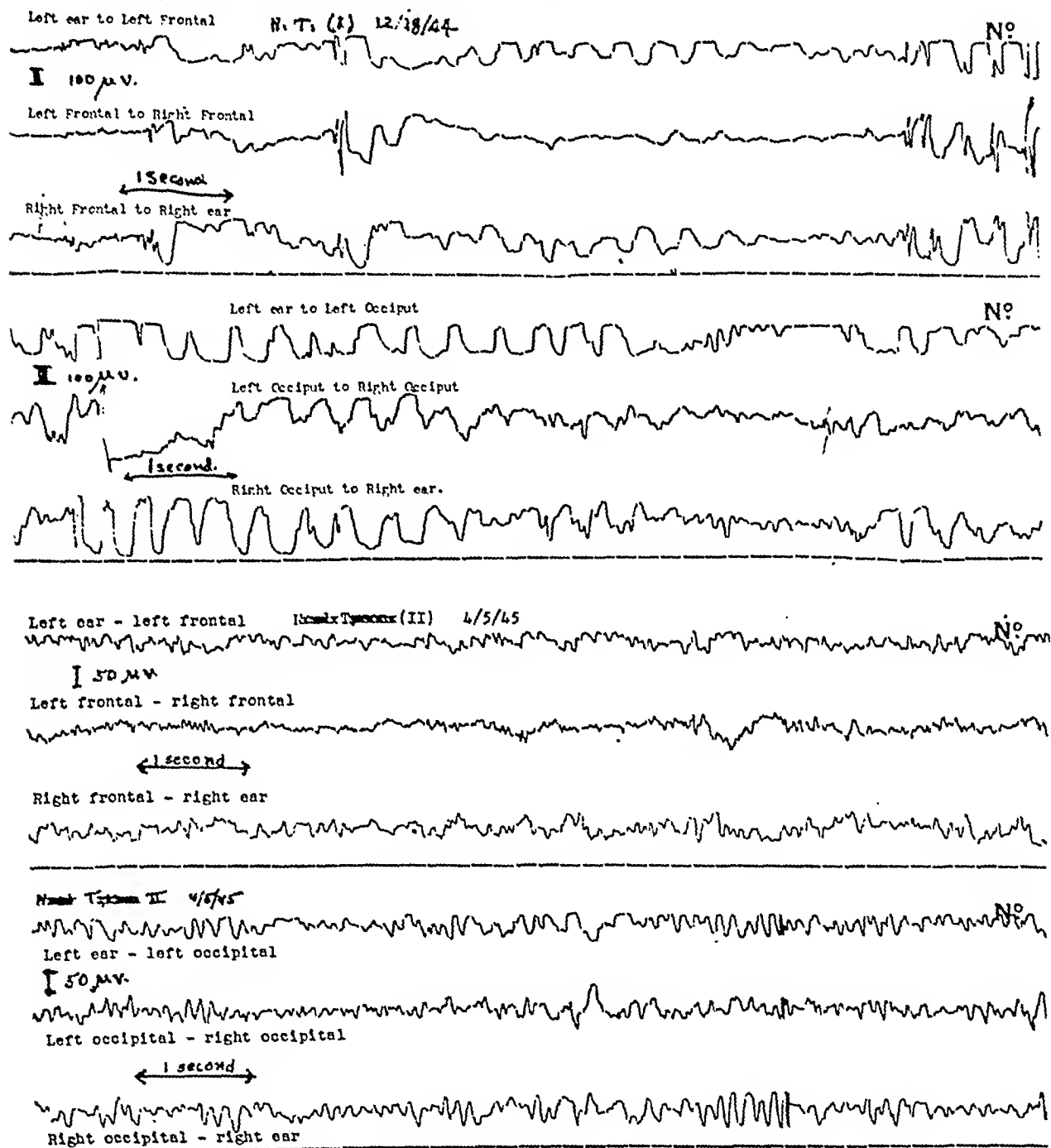


FIG. 5. (Case III). Electroencephalographic tracing during treatment. (Courtesy J. A. M. A.)

11, 1944. There were numerous interval seizures of abdominal pain, nausea, occasional vomiting and diarrhea. The abdominal pain came on intermittently and consisted of "waves" of abdominal pain occurring about twice weekly. The individual attacks of abdominal pain would last from two to three minutes and appeared at intervals of from two to ten minutes, the entire "wave" lasting approximately one hour. These "waves" of pain appeared either in the early morning or at

night and were not associated with unconsciousness or diarrhea. He had one severe attack of abdominal pain in July, 1944, which endured ten minutes and which was followed by vomiting and diarrhea. During the year preceding examination he had frequent nightmares and talked in his sleep. This patient had sustained a severe head injury five years before. While sledding down an incline he struck his head and was unconscious for twenty-four hours. The outstanding symptoms which fol-



Fig. 6. Cortical damage due to craniocerebral trauma. (Toluidin blue stain $\times 100$.)

lowed the head injury were recurrent episodes of abdominal pain interspersed with occasional convulsive seizures and unconsciousness. It was believed that the entire constellation was a form of epilepsy resulting from injury to the cerebral cortex. Electroencephalographic studies as shown in the illustration (Fig. 4) revealed slow waves which could be seen in all leads. These slow waves seemed to predominate and were more persistent in the frontal areas. It was concluded by Dr. Donald Scott, the encephalographist, that "the record most closely approximated the pattern seen in idiopathic epilepsy."

This patient was subsequently placed on an anti-convulsant therapeutic regimen consisting of dietary control, supervision of activities, and medication in the form of diphenylhydantoin sodium (dilantin sodium) gr. $1\frac{1}{2}$ twice daily and calcium-bromido-galactogluconate (Calci-bronat—Sandoz) 2 Gm. dissolved in water three times daily. Immediately after being placed on this form of therapy the attacks of abdominal pain ceased and to the present writing, one year and five months after treatment was started, this patient has had no abdominal pain and no grand mal seizures. Subsequent electroencephalographic tests (Fig. 5) with the patient on medication showed the usual level of normal activity with groups of slow waves both with and without spikes. The latter occurred most prominently in the frontal and occipital regions. This record showed 30 per cent less abnormal activity than the previous study.

This patient had had three attacks of incomplete convulsive seizures during a five-year period following severe head injury. The predominant feature during that interval had been recurrent attacks of abdominal pain coming on at frequent intervals. These had been misinterpreted completely and eluded treatment until anti-convulsant therapy was instituted, since which time there has been a complete cessation of symptoms.

This case illustrates the relationship between cerebral injury producing cortical damage and the resultant abnormal discharges from the adjacent cortical neurones, as graphically demonstrated by the electroencephalographic studies, resulting in paroxysmal abdominal pain (due to involvement of the frontal and/or parietal lobes) or convulsive seizures (due to implication of the motor cortex). The photomicrograph (Fig. 6) shows the degree of cortical damage which may result from cerebral trauma, and the ganglion cells in the immediate periphery of such lesions may be the origin of abnormal discharges capable of being picked up by the electroencephalograph.

CASE IV.¹⁷ (Angioneurotic edema of the brain with focal cortical damage.) P. P., male, aged thirty-seven, was first seen by me in June, 1941. The chief complaint was the single

symptom of periodic attacks of severe cramp-like pain involving the entire abdomen. The pain often started in the lower right quadrant and then involved the whole abdomen. Individual attacks of pain endured up to two hours or more and were intense and unrelenting. During the attack there was a "rumbling" sensation in the abdomen. When the attack of pain subsided, he was exhausted and felt "achey all over." The bouts of pain began at the age of nine months and occurred at irregular intervals, appearing every seven or eight days for months preceding my original examination, and during the week preceding the examination four seizures had occurred. The first attack came on shortly after the patient had received diphtheria antitoxin, which had made him quite ill. When eight years of age an appendectomy was performed during one of the seizures and a normal appendix was removed. At the age of sixteen he injured himself and anti-tetanus serum was given. He became extremely ill and experienced one of his usual attacks of intense abdominal pain. He also had urticaria and a high degree of fever for two days thereafter. There was a history of development of hives after eating certain foods. This patient had been studied thoroughly in many institutions over a period of practically the entire range of his illness. The types of treatment were many, but at no time did he obtain lasting relief. The longest attack free interval was fourteen months. An objective neurological examination failed to reveal any evidence of overt disturbance of the nervous system. Complete studies with respect to cytology, blood and spinal fluid chemistry, x-ray studies of the gastrointestinal tract, gallbladder and urinary tract, all proved negative. The blood pressure was 102 systolic, 68 diastolic, pulse rate 76, weight 139½ pounds. During the study of this patient it occurred to the examiner that the symptom of abdominal pain, in view of its irregular occurrence, paroxysmal nature, duration of the seizure, and the post-seizure statement by the patient that he was "exhausted and felt achey all over," a frequently observed phenomenon in the postconvulsive phase of epilepsy, represented a form of epileptic disturbance.

In order to ascertain the correctness of this point of view, two steps were pursued; the first consisted of having electro-encephalographic studies performed, and the other to place the

patient upon an anti-convulsant regimen. These studies revealed the presence of abnormal low voltage waves seen mainly in the right and left frontal regions. They were also present in the parietal and occipital lobes. Hyperventilation increased this abnormal activity. (Fig. 7.) Anticonvulsant medication was begun during the middle of June, 1941. This consisted of phenytoin sodium (dilantin sodium) 1½ gr. (0.1 Gm.) twice daily and a bromide mixture, 1 fluid dr. (4 cc.) four times daily. For a period of over seven and one-half months he remained attack free, following which he was requested to stop medication in order to determine whether the seizures would return. Within a period of less than a month, he developed a severe attack. Medication was resumed and he remained attack-free for seven and one-half months, at which time the dilantin sodium was replaced by lactose in the white and red ringed capsule and the bromides replaced by sodium chloride. This was done without the patient's knowledge in order to eliminate the element of suggestion. Fifteen days later he developed the characteristic seizure. He was informed about the experiment after his extreme alarm at the reappearance of the attack. This patient has remained attack free from July, 1942, to the present writing, April, 1946, with only two exceptions which occurred during the latter part of 1945 when the patient had grippe and stopped taking the anti-convulsant medication, and during the early part of 1946 when he had again lapsed in the use of dilantin sodium and the bromide mixture. During the period of three and one-half years between July, 1942, and December, 1945, he was entirely free of seizures and took the dilantin sodium faithfully and the bromide mixture somewhat irregularly. Electro-encephalographic studies performed during the time he was on active treatment (Fig. 8) showed that the cerebral potentials in both hemispheres were within normal limits. There was an occasional abnormal sharp wave. Large, slow, abnormal waves could be brought out in both frontal lobes after hyperventilation.

This patient had an exquisitely defined symptom of abdominal pain without any preceding phenomena and following an attack only the experience of exhaustion and achiness. The question as to whether this might be abdominal migraine had been eliminated diagnostically, first because this diagnosis had been made in

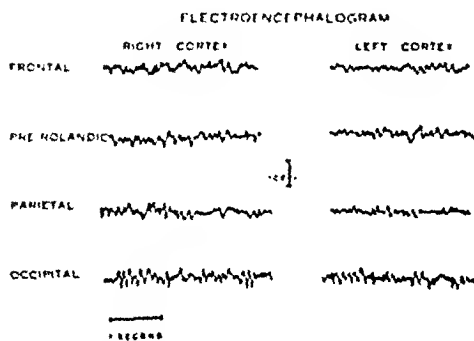


FIG. 7. (Case iv). Electroencephalographic tracing prior to treatment, showing low voltage three per second abnormal waves in the right and left frontal cortex. They are present to a lesser extent in the parietal and occipital areas. (Courtesy J. A. M. A.)

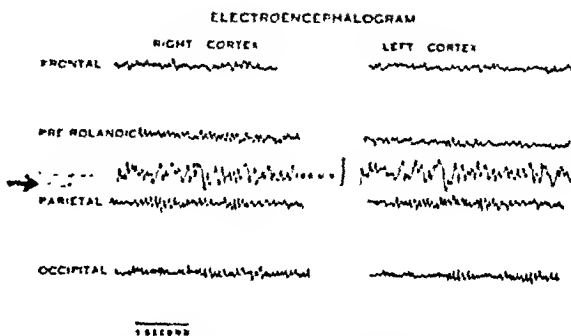


FIG. 8. (Case iv). Electroencephalographic tracing during treatment with anticonvulsants. The cerebral potentials throughout both hemispheres are within normal limits as to amplitude and rhythm. After hyperventilation, denoted by arrow, large slow abnormal waves are detected in both frontal lobes. (Courtesy J. A. M. A.)

one of the hospitals where he had been examined and the use of ergotamine tartrate failed to prevent attacks or abort one in progress. Furthermore, the usual history of abdominal migraine was absent. That is, other migrainous phenomena failed to appear such as hemicrania preceding or following the attack of abdominal pain, visual disturbance, nausea, vomiting or diarrhea. The pattern of the occurrence of abdominal pain coming on suddenly, at irregular intervals, and presenting a stereotyped form, suggested the epileptic nature of the disorder. It was believed that the disturbance probably arose in those cortical areas of the brain subserving gastrointestinal function and that the original use of serum, when the patient was nine months of age, probably had produced angioneurotic edema of the brain with some alteration of structure in the areas stated. That such a point of view is justifiable is based upon the experimental and clinical observations of Dechaume and Croizat¹⁸ and Bassoe,¹⁹ and the objective electroencephalographic findings of abnormal activity in the frontal and parietal lobes. Dechaume and Croizat¹⁸ experimentally produced congestive, hemorrhagic and degenerative changes in the brain following serum shock in animals. The case reported by Bassoe¹⁹ of a woman who developed aphasia, hemiplegia, hemianopsia and convulsive seizures following the injection of serum, showed upon exploratory craniotomy an area of dark, hyperemic softened brain tissue, which was regarded as the effect of a focal angioneurotic edema of the brain.

This case illustrates the development of

the symptom of paroxysmal abdominal pain in an individual in whose brain changes had occurred following the use of an antiserum. Specifically, angioneurotic edema is postulated to have occurred with subsequent damage to the cortical neurones of the cerebral cortex, mainly in the frontal lobes and to a lesser degree in the parietal lobe. These areas of altered tissue have provoked a cerebral dysrhythmia as seen in the electro-encephalographic studies, and when the appropriate factor or factors were present, such as the reaction set up by certain foods to which he had been shown to be allergic, the process of summation in the irritated ganglion cells was invoked eventuating in the explosive discharge producing hypermotility of the bowel and abdominal pain.

CASE V.²⁰ (Isolated symptom of paroxysmal abdominal pain without demonstrable etiology.) P. P., a married female, aged forty-four, complained of bouts of abdominal pain, beginning twelve years prior to the date of examination on May 4, 1944. Two years after the onset of her repeated abdominal pain, she had her appendix removed. The latter showed no morbid process. The attacks began with a peculiar sensation of "gnawing in the abdomen" which was then followed by generalized pain. The latter was accompanied by a "rumbling noise in the intestine." The abdominal pain at times was associated with a "funny, dazed feeling" and at such times she

feared that she was going to "pass out." The attacks of abdominal pain appeared for the most part at night. She always maintained consciousness throughout these seizures. During the twelve-year span there were three occasions, all of which occurred while in bed, in which the abdominal pain was associated with a "shaking" of her limbs and jaw, which she was unable to control voluntarily. The latter episodes lasted from ten to fifteen minutes and would awaken her from sleep. There were no premonitory symptoms other than the "gnawing" sensation cited above. The seizures occurred about twice weekly for the four-month period preceding examination. Her attack free intervals usually lasted no longer than one week. She had been married nineteen years and the past medical history revealed no data which would throw any light on the possible etiologic cause. From the time of her appendectomy, she had consulted numerous physicians and was ultimately labelled a psychoneurotic. A review of her personality development and the psychiatric examination showed no disturbance in her emotional or mental spheres. There was no evidence of organic disturbance of the nervous system following a detailed neurological examination. X-ray studies of the gastrointestinal tract and laboratory studies showed normal findings during the attack free intervals. Physical examination of the chest and abdomen likewise was negative. Electroencephalographic studies revealed no abnormal cerebral discharges.

Despite the fact that this patient presented no previous history of cerebral injury or disease predisposing to changes in the brain or meninges, it was believed, because of the several facts, such as the periodicity of the attacks, their sudden explosive onset, the occasional aura-like introduction by a "gnawing" sensation in the abdomen, the "funny, dazed feeling" and the pseudoconvulsive movements which had occurred in a few of the seizures, that when pieced together, these fitted into the pattern of an epileptic display. This patient was put on an anti-convulsant regimen, the medication consisting of hydantoin sodium $1\frac{1}{2}$ gr. (0.1 Gm.) twice daily and phenobarbital gr. $\frac{3}{4}$ (16 mg.) three times daily. Within one week after the institution of treatment on April 24, 1944, the attacks of abdominal pain disappeared and she has remained attack free since that time.

The only elements in this case which appear to warrant and justify the diagnosis of abdominal epilepsy are (1) the epileptic pattern of the aura-like manifestations, the manner of occurrence of the abdominal pain and the accompanying epileptoid symptoms; (2) the immediate and continued response to anti-convulsants.

COMMENTS

The five cases which have been summarized in brief fashion represent a variety of causes which may produce the symptom of abdominal pain as an expression of altered changes of gastrointestinal motility effected by the remote disturbances occurring in the cerebral cortex, mainly in areas six, five and three. They also represent the illustrative cases of a larger series in which the most frequent cause appears to be cranio cerebral injury.²¹

Case 1 demonstrates perhaps most clearly a specific locale as to the origin of abnormal discharges provoking the symptom of abdominal pain. In this case the abdominal pain was first thought to be of intrinsic gastrointestinal origin. The surrounding historical data, such as headache, mental change, and the neurological findings of increased intracranial pressure, hemiparesis, grasp reflex, altered tendon reflex activity, etc., led to the consideration of a cerebral neoplasm. The operative finding of a discrete tumor lying directly beneath area six in the cortex, would seem to be ample indication of a causal relationship between "irritation" of the neurones in this area and the symptom of abdominal pain. The explanation for the other frontal lobe signs and symptoms, such as mild motor weakness, grasp reflex, occasional hebetic and tendon reflex phenomena, may be based on the glial reaction and swelling of the tissue surrounding the discrete tumor mass. The topographical situation of the tumor in this case clinically bears out the experimental findings of Fulton and his co-workers² and of Spiegel et al.³ Unfortunately, time and lack of facilities did not permit of electro-encephalographic studies

being performed in this case. Had they been done, however, it is not at all unlikely that focal abnormal discharges would have been picked up at the periphery of the lesion in area six.²² It is only a step, therefore, beyond this to interpret positive, abnormal electroencephalographic findings from the frontal lobes and/or the parietal area in cases in which abdominal epilepsy exists as evidence of an intrinsic disorder of, or morphologically altered, cerebral cortex in areas six, five, or three. The alterations of structure in these regions may be due to one of numerous conditions, most of which have already been well outlined by Cobb.²³

For purposes of illustrating the mode of study in this type of disorder I shall cite merely a few conditions which may be predisposing factors in the syndrome of abdominal epilepsy. The existence of a gross lesion such as tumor, abscess, intracerebral hemorrhage, thrombosis of a cerebral vessel, are both clinically and pathologically demonstrable as involving either the frontal or parietal lobes. When the symptom of abdominal pain occurs under such circumstances, it can be attributed to stimulation of cortical areas six, five or three. At times the abdominal pain is the direct result of massive stimulation of the neurones in these areas as in an ictus due to hemorrhage or thrombosis. However, in brain tumor, as in the case reported here and in cases in which the pain was paroxysmal, there must, therefore, be an explanation other than continuous "irritation" which provokes the "seizures of pain," just as there must be some explanation for the periodic fits in the classical form of grand-mal epilepsy. An effort at explanation of this will be offered later. Brain tumor is a notable cause of epileptic fits as has been shown by an extensive literature on the subject.²⁴ The cases of cranio-cerebral injury previously reported by me¹ in which the symptom of paroxysmal abdominal pain was an outstanding feature, I believe to be a demonstration of cortical scars occurring in areas six, five, or three. The

illustration of the cerebral cortex (Fig. 6) of an individual who sustained a cranio-cerebral injury, shows the damage to the functioning cortex and the definite morphologic changes which occur. The functioning neurones at the periphery or in the vicinity of such a lesion may and do give off abnormal discharges, which under appropriate conditions may be of such magnitude as to constitute an adequate stimulus to an effector structure. The scars consequent to brain injury can be seen directly at operative exploration.⁵ They also frequently can be demonstrated by electroencephalographic studies after a definite history of brain injury is in evidence.

It is well established both clinically and neurohistopathologically that infections of the brain and the meninges, especially the latter, may produce fixed tissue changes which may ultimately manifest themselves in disturbed function of the affected brain in the form of convulsive seizures. Here then, is another cause which, if the lesion or lesions occur in areas six, five or three, may produce the symptom of abdominal pain either singly if the lesion is exquisitely placed, or in association with other manifestations of the epileptic state.

Disseminated lesions of the brain offer by mathematical chance a greater likelihood of one or more of the lesions being placed in areas six, five or three, producing the symptom of abdominal pain. Case 11 illustrates this. Other conditions such as multiple sclerosis in which the brain has become involved, Schilder's disease, toxoplasmosis, multiple cerebral arteriosclerotic scars and the like, may also involve areas six, five or three, producing the symptom of abdominal pain, usually in conjunction with other symptoms reflecting the function of the involved brain. Figure 9 illustrates the nature and extent of a cortical arteriosclerotic scar which conceivably could be a single scar involving one of the cortical areas under discussion. Under such circumstances a patient could have the isolated symptom of paroxysmal abdominal pain, and clinically one can imagine the

many conditions which probably would be considered first in the way of intrinsic abdominal disease before relating the symptom of abdominal pain to a possible cerebral cause. Other conditions provocative of structural cerebral change may be toxins of various types. Specifically metallic poisonings, the main offender being lead, may produce changes either of a minimal degree or more extensive disseminated changes in the brain. The form of lead encephalopathy encountered in infancy or childhood producing mild symptoms, may ensue in recovery, because of the relatively minimal damage to the brain. Figure 10 shows an area of the cerebral cortex of a case of lead encephalopathy in which there is a small focal alteration with destruction of neurones, and changes in the ganglion cells in the immediate vicinity of the focal devastation. It will be seen that the endothelial nuclei of the capillaries are swollen and where they oppose each other cause a slowing up or stoppage of blood flow with resultant dropping out of cells, and ischemic cell changes of other neurones in the area supplied by the vessels.²⁵ It is from such lesions which may or may not ultimately cause electroencephalographic abnormalities and which may not be surmised unless an extremely careful history is obtained, that the symptom of abdominal pain may occur either singly or in association with other larval or aberrant displays of epilepsy.¹⁵ This together with other noxious agents, such as the cerebral reactions to sera, vaccines, high fever and the secondary encephalopathies incident to measles, scarlet fever and other infections²⁶ constitute a group of causes which may occur at any time after the birth of the individual, and which if the lesion or lesions be situated as already mentioned, the symptom of abdominal pain can and does occur. Intra-uterine existence does not protect the fetus from contracting some type of cerebral affection which may ultimately produce a form of epileptic disorder. It has been shown that the cerebral lesions of toxoplasmosis begin in utero²⁷ and clinically



FIG. 9. Arteriosclerotic scar producing "puckering" of the cerebral cortex. (Klarfeld stain $\times 65$.)

this condition is characterized, among other things, by convulsive seizures. Should lesions in this condition affect only cortical areas six, five and three, one can see the causal relationship with abdominal pain. Other conditions of ante-natal origin²⁸ are likewise known to result in epileptic seizures.

A less easily demonstrable, but equally important consideration of what may be a factor in unexplained paroxysmal abdominal pain occurring both in children and in adolescents may be the minimal neurohistological changes which are produced in the brain of the fetus secondary to febrile or toxic conditions occurring in the mother during the period of gestation. Figure 11 shows a focal area, one of many, which occurs in the brain of an individual suffering from toxemia of pregnancy. There are changes in the small vessels, particularly the capillaries, in which there is endothelial thickening, resulting in focal areas of cellular devastation and severe cell disease. Other areas may show ischemic cell

FIG. 10.

FIG. 11.

FIG. 10. Lead encephalopathy, showing focal cortical area of cellular devastation, intimal changes in the capillaries and cell disease of the adjacent ganglion cells. (Toluidine blue stain $\times 210$.)

FIG. 11. Toxemia of pregnancy, showing focal cortical damage, with an acellular area, capillary proliferation and gliosis. (Toluidine blue stain $\times 210$.)

disease secondary to the disturbance of circulation in the small vessels. The biochemical disturbances which constitute the condition known as toxemia of pregnancy are operative not only on the cerebral tissues of the mother, but certainly must affect the more vulnerable brain of the fetus also. In those individuals in whom toxemia of pregnancy subsides under proper treatment and where the delivered infant survives, it is not taxing credulity to visualize at least a few such areas, as

shown in the illustration, in the brain of the surviving offspring.

Again, braving the criticism of repetition, a lesion of this sort in areas six, five or three presumably could eventuate in disturbance of gastrointestinal motility, giving the clinical picture of abdominal epilepsy, or perhaps in other forms of gastrointestinal syndromes, which to the present have escaped acceptable explanation. Further study along the lines of electroencephalographic findings in various gastrointestinal

disorders, characterized by changes in motility, may yield fruitful information with respect to cerebral disorders. This tenuous hypothesis may be borne out somewhat by the case previously reported by me,¹ in which the forty-three year old patient, over a period of many years, had had abdominal symptoms consisting of paroxysmal abdominal pain, "rumbling" of the bowel and diarrhea. These gastrointestinal manifestations were at times associated with vasomotor phenomena and occasional unconsciousness and muscular twitchings. He had been considered at various times as having enterocolitis, duodenitis, spastic colon and the like. Treatment with an anti-convulsant regimen provided relief for the first time since the age of twelve when the attacks were initiated.

MECHANISM OF ABDOMINAL EPILEPSY

The various factors concerned in the initiation and discharge of an adequate stimulus from cerebral neurones to effector structures resulting in paroxysmal abdominal pain are in no way different from those operative in the generally accepted forms of symptomatic epilepsy. A discussion of the literature and theoretical aspects of the mechanism of the epileptic discharge would lead too far afield and finally would reveal only the open question as to the ultimate nature of the "trigger" factor or factors.

Electroencephalographic abnormalities as a graphic reflection of underlying cortical disturbances have been reported in conditions too numerous to mention here and range from the gross space-taking lesion to the finer lesions of microscopic size.²⁹ In an electroencephalographic study of four cases of encephalitis and meningo-encephalitis, Ross³⁰ showed non-specific electroencephalographic abnormalities in the acute phase of the disease. He also indicated that the abnormal discharges may persist and be the harbinger of epilepsy.

In 1924, Harris³¹ reported five cases of spontaneous hypoglycemia wherein the symptoms of excessive hunger, weakness, nervousness and anxiety were predominant, and in several patients abdominal distress was an added outstanding feature. Bulatao and Carlson,³² in experimentally insulin-induced hypoglycemia in man and animals, observed an increase in gastric tone and in the height and frequency of contractions gradually developing into tetany. The abdominal pain thus induced could be either generalized or localized depending on the extent of bowel stimulated. Hoefer et al.³³ studied a group of twenty-seven patients having verified islet cell adenoma of the pancreas, with respect to the neuropsychiatric manifestations of "convulsions, coma, and related states of impaired consciousness." Among twenty-two of these patients having "autonomic, visceral symptoms," four had abdominal pain. Eleven of these had electroencephalographic studies and eight records taken during the fasting state showed abnormal discharges, among which were synchronous bursts diffusely scattered of the spike-and-wave variety, and others of the slow activity.

Extensive studies by Gellhorn³⁴ have indicated that an "anoxidative state" in the brain is induced by hypoglycemia, metrazol convulsions, injections of sodium cyanide and inhalation of high concentrations of carbon dioxide. Gibbs, et al.³⁵ stated, "nitrogen breathing, standing with a lowered blood pressure and over-ventilation, all of which produced large, slow waves in normal subjects, also tend to precipitate seizures in epileptic persons." Putnam and Hoefer³⁶ have shown, by means of the electroencephalograph, abnormal cerebral discharges in conditions associated with lowered metabolism of the cerebral neurones with special reference to anoxia, and disturbances of carbohydrate metabolism. They made the significant observation "that depression of metabolic function may precipitate an increase in cerebral activity under a variety of con-

ditions and that impaired consciousness and increased neuronal activity are compatible." Thus any of the numerous physiologic and organic disorders, which disturb carbohydrate metabolism, or which induce cerebral anoxia, may lead to abnormal discharges from cerebral neurones.

It will be seen from the foregoing briefly submitted data that two groups of conditions can provide a milieu conducive to setting off abnormal electrical discharges from cerebral tissue, capable of being perceived electro-encephalographically. The first is concerned with definite structural alterations of brain tissue of varying types and causes which may, under "appropriate" conditions, "fire off" and provide an epileptic display. The second group deals with biophysiochemical disturbances which, in the final analysis, produce a deficient oxygen up-take and impoverished carbohydrate supply to the functioning neurone.

It is believed, therefore, that in those fixed morbid tissue changes of the brain the ganglion cells in the vicinity of the lesion may give off a continuous subliminal discharge; and when bodily disorders, whatever their origin, provoke the second factor of disturbed oxygen and carbohydrate metabolism of the brain, which likewise may induce a subliminal discharge, the latter thereby constitutes the "appropriate" condition which by "summation" provides the "adequate" stimulus to an effector organ. In the present case the effector organ is the terminal motor-swelling in the smooth muscle of the bowel. The pain is due to the disordered motility of the gastrointestinal tract and is transmitted by the afferent projection pathways.

Method of Study. 1. *Anamnesis:* This should be painstaking, detailed and exhaustive, and should include all historical data pertaining to the progenitors, physical state of the mother during gestation, evidence of birth trauma, allergic phenomena during and subsequent to infancy, infectious diseases of childhood and all other

infections, craniocerebral injury, endocrine and metabolic disturbances, and all other organic conditions which required medical or surgical treatment. The symptom of abdominal pain should be considered with respect to age of onset, frequency and rapidity of appearance, time of day (pre- or post-prandial), duration, association of pre- or post-seizure sensory phenomena, accompanying symptoms usually associated with the epileptic state, or epileptic phenomena antedating the presenting episodes of abdominal pain, and symptoms referable to increased intracranial pressure or active cerebral disease or dysfunction. I cannot emphasize too strongly the value of an adequate history, which in most instances should often suffice to indicate the proper direction toward correct diagnosis.

2. Each patient should be examined intensively, by the indicated available methods, to rule out the existence of (1) intrinsic disease of the abdominal, pelvic and thoracic viscera, (2) metabolic or endocrine disorders, (3) morbid involvement of the spinal cord or peripheral nerves, and (4) psychosomatic projection mechanisms.

3. Thorough neurological examination and complete laboratory investigation, should, when indicated, include cytologic and chemical studies, roentgenologic studies of the skull,—both direct and contrast (pneumo-encephalography and thorotrast cerebral angiography) and electro-encephalographic studies, should be employed to disclose the presence of some structural or physiologic disorder of the brain residing in cortical areas six, five or three and/or the diencephalon.

4. Finally, resort to the empirical method of the therapeutic test may be the only or corroborative evidence of the existence of abdominal epilepsy. Should the symptom of paroxysmal abdominal pain disappear or be radically altered by an anti-convulsant regimen, recur upon cessation of treatment and again yield to active therapy, the requirements of an ac-

ceptable therapeutic test will have been met.

Treatment. When the collective data reveal the presence of an intracranial space-taking lesion, surgical intervention, in operable cases, is indicated. Focal traumatic scars likewise should be excised, when the symptom of paroxysmal abdominal pain and any attendant phenomena cannot be controlled by an anti-convulsant regimen. Those conditions which may disturb carbohydrate metabolism and/or oxygen supply of the cerebral neurones thus providing the biochemical "trigger factor" in the production of abdominal pain, such as hyperinsulinism, hyperthyroidism, congestive heart failure, Adams-Stokes disease, intoxications, allergies, blood dyscrasias and the like, should receive treatment specifically directed. If cerebral syphilis is uncovered during the study for the cause of abdominal pain the obvious treatment is anti-luetic. Foci of infection should be eradicated and attention should be directed to factors which might precipitate reflex afferent stimuli.

The fixed morphologic cerebral changes and the biochemically altered cortical cells, already alluded to and not amenable to surgical treatment, which act as the sources of abnormal electrical discharges producing paroxysmal abdominal pain should be treated by the following anti-convulsant regimen: (1) The use singly or preferably in combination of (a) diphenylhydantoin sodium (dilantin sodium), (b) phenobarbital, (c) bromides—alkaline or calcium bromido-galactogluconate (calcibronat). These drugs are to be used in adequate dosage depending upon age, weight and habitus of the patient; (2) high vitamin, high protein, moderate fat, moderate carbohydrate diet; (3) controlled liquid intake, adequate to meet the daily needs of a balanced water metabolism. This means neither dehydration nor water intoxication; (4) supervised social, physical and emotional activities within reasonable limits, designed to establish an even tenor of living.

SUMMARY AND CONCLUSION

Attention has been directed to a form of abdominal pain which represents the symptomatic projection of distant cerebral disease or dysfunction.

Experimental and clinical data are presented indicating the relationship of abnormal gastrointestinal motility and abdominal pain, with lesions affecting cortical areas six, five and three and/or the diencephalon.

Allusion is made to some of the various morbid organic changes, and other disorders which may result in less easily demonstrable neuropathologic conditions, which may provoke abnormal electrical discharges in those areas subserving gastrointestinal function, thus providing the stimulus for altered motility of the bowel ending in the symptom of abdominal pain.

Representative cases are cited to illustrate the location of definable gross cerebral lesions capable of visual observation, and others, due to a variety of causes, demonstrable by electro-encephalography, which are believed to be the origin for the symptom of paroxysmal abdominal pain.

An effort is made to describe and define, with sufficient inclusiveness, a syndrome which provides the essentials for definitive diagnosis without resorting to a diagnosis by exclusion; and a tentative explanation of the mechanism of symptomatic abdominal epilepsy is submitted.

The method of study and treatment are outlined.

The symptom of paroxysmal abdominal pain, when properly fitted into the pattern of historical events and symptoms, in the light of the foregoing presented data, may be considered not only as a form of symptomatic abdominal epilepsy but also may serve as a guide-post in the topographical localization of cerebral lesions.

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DISRUPTION or eventration of abdominal wounds usually occurs between the seventh and eleventh days after operation, after the use of vertical incisions closed with catgut. Wound infection, drainage, cough or other strain favors the disruption. After a secondary closure, a secondary eventration may occur.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

PREOPERATIVE AND POSTOPERATIVE CARE OF ACUTE SURGICAL CONDITIONS OF THE ABDOMEN*

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THE surgeon long ago established his art upon the basic fundamentals of asepsis, hemostasis, gentle handling of tissues, astute diagnostic ability and personal integrity. The past fifteen years have brought many improvements in surgical technic but the reduction of surgical morbidity and mortality has been greatest since these fundamentals were combined with skilled preoperative and postoperative care. The more acute the surgical condition, the more applicable becomes this statement. Thus is affirmed the pertinent fact that surgical technic must not be divorced from surgical therapeutics. This is the thought Sir William Osler sought to convey when he stated, "A surgeon should be a physician who operates." Careful preoperative and postoperative care can virtually fulfill Lord Moynihan's desire that, "Surgery has been made safe for the patient and now the patient must be made safe for surgery." There are very few surgical emergencies that do not permit fundamental preoperative care and all surgical patients merit enlightened postoperative care. This applies to every operative procedure as not one is of "minor" surgical status. Surgery of any nature can be a dangerous method of therapy.¹

PREOPERATIVE TREATMENT

When a patient suffering from an acute surgical condition of the abdomen presents himself, the surgeon does more than evaluate the primary disorder. It is necessary to weigh the severity of pain, amount of anxiety, possibility of shock, presence of dehydration, existence of hemorrhage, probability of infection, the nutritional state and concurrent disease. To answer and thus

effectively deal with these problems an inventory must be taken. This includes a history, physical examination and a laboratory investigation.

Inventory. This period, short though it may be, allows for careful surgical planning. The surgeon seeks to secure the patient's confidence and cooperation.² Failure to prepare a patient psychologically may complicate skilled surgery or minimize its benefits. A methodical history not only aids in revealing the proper diagnosis but provides an orderly, useful source of material for later analysis. It may ward off complications by the patient revealing such conditions as a drug idiosyncrasy, alcoholism or a state of hemophilia.³ In this manner the physician not only wins the patient's regard by his interest and thoroughness but is rewarded by facts that contribute to a purposeful diagnostic pattern.

A physical examination should be a well planned, conscientious search for every vestige of information pointing to the patient's specific complaint and his general state of being. More diagnostic errors are committed from lack of observation, or slipshod interpretation than from not knowing the disease *per se*.⁴ Too frequently an examination includes only the region of apparent pathological disorder. Do not formulate a diagnosis on impression; gather facts, all the facts. During an examination it is well to have the patient alone, well covered, as comfortable as possible, in good light and with the bladder and rectum empty. The examiner should gently proceed with an orderly, complete scrutiny, keeping his eyes and ears alert. Examine the suspected area last. Record at once in writing the findings and impressions. Such

* From The Department of Surgery of The Jackson Clinic, Madison, Wisconsin.

a commitment stands later as irrefutable evidence of one's diagnostic skill or of its lack.

The laboratory offers valuable assistance in the preoperative examination. Certain tests will be utilized to evaluate the specific surgical complaint, others to reveal the patient's general surgical status. For example, an elevation of the blood's non-protein nitrogen may necessitate a careful genitourinary tract investigation, or call for dietary or medical management; it may influence the choice of anesthesia and the extent of purposed surgery. A hemoglobin value below 60 per cent may be ominous.⁵ The presence of an elevated blood pressure is cause for vigilance; a very low blood pressure is cause for concern. A normal electrocardiogram is a vote of confidence but not insurance against cardiac complications. It is in this manner the surgeon evaluates the many aids the laboratory can offer. When properly selected a laboratory investigation can reasonably predict a patient's surgical tolerance.

Immediate Preoperative Period. This period covering from a few minutes to several hours must be expertly utilized as every minute counts. The surgeon need be explicit in his instructions to his surgical assistants and the nursing staff. Standing orders which are generally applicable to patients with acute surgical conditions of the abdomen include:

Record your observations of the patient's pertinent actions and comments.

Call the laboratory at once for desired tests and assist in obtaining specimens.

Give nothing by mouth and aspirate (do not wash) the stomach if food has been recently taken.

Pass a Levin catheter through the nostril and institute gastric suction.

Oral hygiene is instigated and false dentures removed from the mouth.

Select and indicate the most acceptable vein for intravenous fluid.

If intravenous fluids are to be started, (1) select a vein not likely to be disturbed, (2) introduce a No. 19 gauge needle, (3)

secure it firmly in place, (4) do not lower the fluid flask or pinch its tubing to check the needles position.

Catheterize female patients and leave a clamped catheter in place.

Catheterize male patients if a residual is suspected. Leave catheter in place if the surgical procedure is apt to prove prolonged.

One and one-half hours before surgery exclude visitors from patient's room.

Cover the eyes with cotton and place cotton fluffs in the ears; hold all in place by a towel fitted to the head.

Administer preoperative medication and request quiet of roommates and hospital personnel.

Note and record patient's general response every thirty minutes thereafter.

Chart, x-rays and special equipment are made ready to accompany the patient.

Deliver the patient to the surgical room at the appointed time.

Preoperative Medication. The choice of preoperative medication is largely determined by the constitutional state of the patient being operated, the procedure to be executed and the anesthetic to be used. Properly administered preoperative medication should relieve the patient's anxiety, reduce or eliminate the excitement stage of anesthesia, minimize the amount of anesthetic required, lessen the tendency to shock and render recovery possible with less effort and fewer complications.⁶ There is no one drug or combination of drugs that is ideal. The amount used must be individualized and under no circumstance should amounts be routinized.⁷ This applies especially to the oft used "quarter and hundred and fiftieth."⁸ Divided doses of preoperative medication are to be preferred to hazarding overdosage. Basal anesthesia should never be allowed to so depress or confuse a patient that he cannot identify himself just before receiving an anesthetic.⁷ All drugs available for preoperative sedation may produce idiosyncracies. Morphine is probably the most frequent offender although probably the most useful drug. Given hypodermically it requires at least

one hour to exert its maximum effect although this action can be obtained in ten minutes if given intravenously.⁸ Barbiturates are especially valuable due to their soporific effect and ability to modify the toxic qualities of a local anesthetic.^{7,9} They are more useful from the standpoint of comfort than they are safe, however.⁸ Scopolamine may occasionally produce periods of excitement. Hyoscine may predispose to more postoperative complications than related drugs.^{9,10} Paraldehyde is a safe and effective drug which may be given orally or rectally.¹¹ The use of atropine sulfate, although time honored, does not merit the tendency to its routine use. In acute abdominal surgery the Jackson Clinic finds frequent use for sodium phenobarbital one and $\frac{1}{2}$ gr. orally or 3 gr. rectally one and one-half hours before surgery. One hour before surgery pantopon $\frac{1}{4}$ gr. and often scopolamine $\frac{1}{150}$ to $\frac{1}{300}$ gr. are given hypodermically.

Skin Preparation. The skin site of a purposed surgical incision should receive careful attention. Gentle cleansing with mild solutions is sufficiently effective to render undesirable harsh scrubbing and strong solutions.¹² The presence of hair in an operative field may not be as surgically offensive as numerous skin nicks made in its unskilled removal. It is well to prepare a large skin area.⁴ Open wounds, the umbilicus and sinuses may be sealed with colodion. Exercising aseptic technic and utilizing white soap, sterile water and cotton balls gently scrub the skin for two minutes. Next shave the area cleanly with a sharp blade, wash away all loose hair and continue gentle scrubbing for eight more minutes. Use plenty of white soap. Rinse the skin with sterile water. If a tinted germicidal dye is desired zephiran (1:000) or merthiolate¹³ are permissible. Skin prepared as just described is as well prepared as by any method. The skin should be prepared just before surgery. In the event that more than an hour elapses after the above preparation and before surgery the skin merits another five minute scrub just

before draping using the above technic. It is well to remember that the skin is not rendered "sterile" by any ritual of preparation, but the method just reiterated has physiological merit and proven virtue.

SPECIAL PREOPERATIVE SURGICAL PROBLEMS

Poor Risk Patients. Many patients who must submit to surgery due to an acute abdominal complaint are poor risks. This condition may be due to the primary disorder but it is often the result of an associated state.^{14,15} The "poor risk" cannot always be anticipated but the very young and the aged are generally not good risks.¹⁶ Children require greater surgical care as they tolerate pain poorly, are emotionally unstable, cooperate reluctantly, are unpredictable in accepting nourishment, fall easy victims to infection and have water, acid-base and nitrogen equilibriums that are readily disturbed.¹⁶ These tendencies demand careful preventive measures. The aged surgical patient is becoming more prevalent. When handled carefully they tolerate surgery well but are more prone to circulatory and renal failure, pulmonary complications, embolic phenomena and slow tissue repair.¹⁷

Diabetic Patients. Joslin states that over 50 per cent of all diabetic patients receive surgical care some time in their life.¹⁸ Statistical studies further show that the number of diabetics has doubled in the United States in the past decade.¹⁸ In emergency surgical cases particularly accompanied by infection the operative risk and mortality are greater in the diabetic.¹⁹ Every effort must be made to control the diabetes as certain symptoms of diabetic acidosis (i.e., nausea, vomiting, abdominal pain and leucocytosis) may simulate or mask an acute surgical condition of the abdomen. Not infrequently an acute abdominal lesion may precipitate a diabetic acidosis.¹⁸ When this occurs, combat dehydration and acidosis with large amounts of fluids, glucose and insulin.²⁰ Keep in mind that the most prominent symptoms of protamine hypoglycemia are nausea, vomiting,

headache and dizziness,²¹ thus rendering differentiation from acidosis at times difficult. Protect the patient with a high carbohydrate intake covered with sufficient insulin as judged by blood sugar determinations. The diabetic subjected to surgery especially when infection is present will demand substantial increases in insulin.^{18,21,22} Spinal anesthesia is ideal for the diabetic patient. Once operated upon the diabetic becomes an excellent candidate for postoperative complications.

Cardiac Patients. Patients with suspected or recognized cardiac lesions cause the surgeon considerable concern. The blood pressure and the electrocardiogram frequently do not aid in evaluating the heart's work capacity. Very often a more valid and simple cardiac test is the heart's response to exercise or the patient's reiteration of his ability to exercise. It is necessary to keep in mind the often wide latitude between heart disease and heart failure. It is true that surgical patients with angina pectoris, syphilitic aortic insufficiency, aortic stenosis and heart block may be subjects for sudden death.²³ Render the cardiac patient free of pain with an opiate, alleviate anxiety by a barbiturate and promptly fortify the heart muscle with digitalis when indicated. During surgery be doubly vigilant to avoid a fall in the blood pressure.²⁴ Following surgery instigate measures to prevent distention and vomiting, assist the patient to move freely, give parenteral fluids slowly and in well tolerated amounts and do not allow the patient to exert himself. The inhalation of oxygen spares the heart, reduces respiratory effort, hastens the recovery of the nerve centers and assists in preventing distention and pulmonary congestion.

Gastrointestinal Patients. Acute disturbances of the gastrointestinal tract early exert a profound biochemical disturbance in the patient. Special evaluation must be given to the presence or absence of obstruction, the electrolytic balance, store of protein and the presence of infection.²⁵ When acutely involved the gastrointestinal tract

must be placed at rest by withholding oral nourishment, emptying the stomach through a Levin catheter and when indicated decompressing the small bowel by means of a Miller-Abbott tube. The value of the Abbott-Rawson tube for simultaneous gastric suction and intestinal alimentation is recognized. In event barium has been administered as a diagnostic medium see that it is removed before surgery. Preoperative catharsis has no place in these cases.¹¹ The value of an enema utilizing a mild solution has its indications. These patients, due to reduced oral intake, vomiting and diarrhea, suffer from water and electrolytic balance disturbances calling for careful but often copious amounts of parenteral fluids. Hypoproteinemia may produce obstructive edema of intestinal suture lines and should be corrected by whole blood and amino acids. The need for additional vitamin C and vitamin B complex is present and vitamin K is of value even though jaundice is not present. Too frequently these patients receive inadequate calories during the first seven, even fourteen days postoperatively. Do not calculate the nourishment intake in terms of cubic centimeters of fluid but rather in calories derived from Grams of carbohydrate, fat and protein.

POSTOPERATIVE TREATMENT

Immediate Postoperative Period. The period immediately following surgery and for four hours thereafter is an especially vital one for the patient.¹⁴ This is all the more true if a general anesthetic has been given. The value of a surgical recovery ward devoted exclusively to postoperative care for the patient's first twelve to thirty-six hours is recognized. In its absence adequate standing orders in the hands of competent lieutenants are essential. Orders applicable to the immediate postoperative period of acute abdominal cases include:

Transferral from operating table: Do not suddenly alter a position that has been long maintained.¹ Support the spine in its physi-

ological position. (The anesthetist at this time will supply a listing of the patient's general state, blood pressure, pulse, respirations and medications recently given).

Transportation on operative cart: Do not leave the patient alone for a moment. Keep him well covered. See that the patient's chart accompanies him.

Transfer from cart to bed: Have the bed warm and flat. Lift, do not drag the patient into bed. Cover lightly (excessive covering contributes to restlessness and water loss by sweating).²⁶ Do not place pillows beneath the knees (they invite vascular complications). A moderate Trendelenburg posture is useful (it aids cerebral circulation, lightens the cardiac load and facilitates bronchial drainage).

Maintain a free airway: Have at hand a mechanical airway, tongue forceps, mouth gag, emesis basin and towel.

Inventory of the patient's condition: Note and record at least every thirty minutes for three to five times the patient's blood pressure, pulse, respirations, etc. Watch dressings for soilage, and properly connect drainage tubes.

Special equipment: Intravenous fluids, gastric suction and intranasal oxygen are used routinely; have the equipment ready.

Assist in recovery of motion: As a patient awakens from a general anesthetic he will often be confused and given to moving about. This is favorable to recovery and sedation should not be given in this "restless" period. Turn or assist the patient to do so. Move the limbs through their range of motion. Encourage deep breathing and gentle coughing.

Bladder care: Aid the patient to urinate. Do not delay catheterization especially when intravenous fluids have been given. When catheterization must be repeated request orders for special bladder care.

Oral hygiene: Moisten the lips, allow the mouth to be rinsed and the teeth to be brushed. Gum may be chewed; later glucose candy sucked upon.

Reassure the patient: Good nursing care allays apprehension, has a sedative effect

and favors the return of physiological processes.

Postoperative Pain. Pain is often the first companion of a patient postoperatively. It is usually preceded by discomfort, restlessness, fatigue and insomnia. It is more readily controlled early in its onset than when anxiety and exhaustion become its comrades.²⁷ When not definitely contraindicated surgical patients deserve sufficient anodyne to provide comfort during the first two or three postoperative days. Morphine or one of its fractions (i.e., pantopon) is the best drug. Demerol is to be recommended for its anodyne and antispasmodic virtues. Such medications do not lend themselves to "p.r.n." ordering or as a compensatory medium for inadequate nursing care or rough surgical technic. Skilled nursing care and judgment in administering an anodyne contributes much to the prevention and to the control of pain. Too frequently a hypnotic drug (i.e., chloral, paraldehyde, bromides, barbiturates, etc.) is administered in hopes that it will relieve pain. These drugs are designed to produce somnolence not to relieve pain. The excellent pain alleviating qualities of acetylsalicylic acid are useful.

Fluids Postoperatively. It is not valid to assume that a patient can readily survive a postoperative period of nutritional withdrawal by calling upon stored constituents. It is true that a preoperative surplus of water, salt, carbohydrate, protein, fat and vitamins fortify in part a patient's postoperative needs, but only for a few hours.²⁸ Ideally all these substances are given orally; however, when this route is not available they are given rectally, subcutaneously, intravenously, intramuscularly, intraperitoneally and so forth. In certain instances one or a combination of these routes may be superior to others. Do not become wedded to any one method. Too frequently the safe, economical and, when properly used, easy administration of rectal nourishment is neglected. Intravenous alimentation is widely utilized and the sub-

sequent comments pertain to this method of fluid administration.

Water. Water constitutes 70 per cent of the body weight and stands second only to oxygen as a vital physiological substance.²⁹ The amount of water received by a surgical patient is as important as the dose of any other potent therapeutic agent.³⁰ Water participates in two major functions, namely, the elimination of waste (via the urine and the bowel) and the dissipation of heat (via sweat and the respiratory tract). The former has first claim upon the body's water and the latter upon that which remains.³¹ The water a surgical patient will require depends upon the amount vaporized, passed as urine, used to replace abnormal losses (i.e., vomiting, drainage, etc.) and that needed to overcome a previous state of dehydration.³² The amount of water necessary to fulfill these needs is not easily ascertained. A number of laboratory tests (i.e., hematocrit determination, blood specific gravity, blood plasma's electrolytic pattern, etc.³³) are of assistance but they are not specific. Certainly the surgeon should not wait for clinical symptoms of dehydration to signal the need for water. Nor should he rely upon an order to "force fluids" which is an unscientific request and if carried out literally could be dangerous.³²

A gross but workable estimate of water balance can be secured by the careful measurement of the amount of fluid consumed and the amount of urine excreted. An output of 500 cc. may be adequate provided the urine is concentrated to a specific gravity of 1.015 or above. Urine whose specific gravity is below 1.015 may require 1,500 cc. to complete its excretory task.³² The average patient will require at least 2,000 cc. of water each twenty-four hours and certain patients may need twice this amount. The amount of water retained within the body depends upon the "holding" qualities of the electrolytic ions (i.e., sodium, potassium, calcium, chloride, etc.).^{15,34} When these components are low, water promptly passes through the renal mechanism and is lost, when present

in excessive amounts water is fixed in the tissues and edema may result.

Salt. The normal salt requirements varies from 5 to 10 Gm. daily which maintains a blood chloride level near 560 mg. per 100 cc. of blood and more than 1 Gm. in the urine. The major functions exerted by salt are: (1) maintenance of the acid-base balance, (2) retention of fluid in cellular tissue, (3) maintenance of tone in the intestinal musculature and (4) it is bactericidal.⁵ The need for salt is markedly increased in the presence of pyrexia, vomiting, diarrhea, aspiration or loss of small bowel content, previous dehydration, etc.³² Symptoms of salt deficiency (hypochloremia) develop when the blood level falls below 450 mg. per 100 cc. The symptoms may include mental depression, fatigue, nausea and stupor.³⁵

So-called physiological saline has become a favorite solution for parenteral administration either alone or as a vehicle. The popularity of this solution is questionable when given in more than 2,000 cc. quantities. One thousand cc. of a 1 per cent solution of sodium chloride supplies the average need of 10 Gm. of salt. The merits of a hypotonic saline solution (i.e., 0.45 per cent sodium chloride) are evident when it is recognized that isotonic and hypertonic sodium chloride solutions may cause fluid withdrawal from the intracellular compartments.³⁶ Ringer's solution has special indications when potassium and calcium are needed.³¹ Hartman's solution is one of choice in the presence of acidosis.⁵

Glucose. Glucose administered intravenously is a ready source of food; it helps prevent acidosis, protects the kidneys by sparing the body's protein, assists the liver to maintain a glycogen balance, acts as a diuretic and is an essential metabolite in muscle contraction, especially of the heart.³ A 5 per cent glucose solution in water is isotonic and provides about one hundred calories per each liter. The body has no difficulty utilizing glucose except when given too rapidly or when a state of diabetes is present. Winslow has shown that the daily

administration of 3,000 cc. of 5 per cent glucose in distilled water given at a rate of 300 to 500 cc. per hour is well tolerated and 98 per cent utilized. (It is well to remember that when 5 per cent glucose is added to a 1 per cent solution of sodium chloride a hypertonic solution results). When additional calories are desired a 10 per cent glucose solution may be utilized although it may temporarily cause tissue dehydration and resulting thirst.

Protein. The necessity of protein for the post-surgical patient has long been recognized but an adequate source and mode of administration is not easily available. The incidence of hypoproteinemia in post-surgical patients is high.^{37,38,39} Those especially prone to develop this condition are patients with bleeding peptic ulcers, cancer of the gastrointestinal tract, bowel obstruction and intestinal fistula.⁴⁰ In the presence of hypoproteinemia fluids tend to leave the blood vessels and the administration of large amounts of sodium chloride solution only accentuates this process. Signs of hypoproteinemia may include lassitude, asthenia, slow wound healing, ascites, edema of suture lines and abdominal distention.^{24,35,41} Blood plasma is a fair source of protein but whole blood is superior due in part to the value of hemoglobin as a protein source. The cost of either substance to combat hypoproteinemia is high as 10,000 cc. of whole blood may be required. To maintain a normal nitrogen balance following surgery as much as 70 Gm. of protein are required each twenty-four hours.³⁹ (1,125 cc. of blood plasma provides approximately 70 Gm. of protein). An amino acid solution prepared by the hydrolysis of casein is available in a 5 per cent concentration. (Amigen is an example). About two-thirds of the contained protein is available (approximately 33 Gm. per 1,000 cc.).³⁵ The solution is in general well tolerated, although relatively expensive and low in protein when used as its sole source. To such a solution may be added glucose, salt, vitamins and sulfanilamide.

Elman³⁸ states "That for surgical or other patients not able to take food by mouth, a simple plan may be drawn up in which all of the nutritional elements can be introduced intravenously in a volume of 3,000 cubic centimeters. This amount of water is probably necessary in most cases for maintaining water balance and providing a urinary output of about 1000 cubic centimeters or more per day. Of the three liters, one liter at least should contain five per cent protein digest and five per cent dextrose. Of the other two liters one will contain five per cent dextrose in water and the other isotonic solution of sodium chloride, which can be injected subcutaneously, thus relieving the patient of the long period required for the administration of three liters of fluid into the vein."

Vitamins. The added need for all the vitamins by surgical patients is well established. Virtually all may be given other than orally. Certain members are more essential than others, namely, vitamin K, C and the B complex. The need for vitamin K (menadione) in the newborn, the pregnant female, jaundiced persons and certain patients with atopy is recognized.⁴² To operate a patient with the prothrombin below 60 per cent of normal is hazardous. The daily dosage of menadione is 2 to 4 mg. It may be given orally, intravenously or intramuscularly. When given orally supply 1 to 3 Gm. of bile salts daily. Cevitamic acid deficiencies occur in starvation, ulcers of the gastrointestinal tract, gastritis and other states. Besides symptoms related to scurvy its deficiency may prevent the proper deposition of collagen in a surgical wound.¹⁴ Vitamin C should be given these patients in amounts ranging from 500 to 1000 mg. daily, taken orally or parenterally. The members of the vitamin B complex are especially indicated in deficiency states, alcoholism, central nervous system disturbances, diabetes, hyperthyroidism and following copious amounts of intravenous fluids. Their dosage under acute surgical circumstances must exceed the therapeutic ones. In administering water

soluble vitamins fractionate the dosage or a wasteful renal spill will occur.⁴³

Oral Nutrition. Following the opening of the abdomen a functional physiologic ileus develops. Its duration depends largely upon the extent and duration of trauma (either chemical or physical) that the abdominal tissues have sustained. Its presence is indicated by an absence of peristalsis and its disappearance by a return of the intestines' normal motility as determined by auscultation. This return may require as long as eighteen hours but this period can be shortened by gentle operative handling of tissues and the judicious administration of oral nourishment. Early feeding tends to decrease so-called gas pains, lessens the possibility of ileus and may assist in preventing a mesenteric thrombosis. The withholding of oral nourishment usually has little place in modern surgical care unless the taking of food jeopardizes the integrity of the intestinal tube itself. In the event a long period of withheld oral nourishment is anticipated as after a gastrectomy, a tube (Abbott-Rawlson or plain catheter) may be introduced through the wound and into the intestine and used as an avenue of nourishment. The problem in every case, however, is an individual one not given to routine consideration. Should nausea develop, vomiting result or intestinal distention ensue it is well to withhold oral nourishment but in their absence oral nutrition may be given shortly after surgery. Liquids of preference include hot water or tea followed by fat-free broth, gelatin, cold water and semi-solid food. By the third day a selected general diet is usually tolerated. Fluids prone to provoke distention include grape juice, orange juice, milk and certain flavored carbonated beverages. Frequently a patient has a consuming desire for a certain food which is often well tolerated when other substances may be rejected. Early oral nutrition often assists the bowel in producing a spontaneous stool circumventing catharsis and enemas.

Ambulation. Sufficient evidence is avail-

able not only to recommend early rising of surgical patients but to demand it. This practice was suggested by Emil Reis of Chicago early as 1889 and followed extensively abroad. It is now receiving its righteous recognition in this country as a major surgical contribution. The empirical use of eight or ten days of postoperative bed rest is in general traditional and unphysiological. Many surgical complications are the direct outgrowth of immobilization associated with bed rest. This is especially true when the abdomen and lower thoracic region is encompassed by a tight binder. Surgical incision plus the binder splint the abdominal muscles, limit the diaphragmatic excursion with resulting tendency to pulmonary complications, reduced cough reflex and lessened vital capacity.⁴⁴ Circulation in and about the wound is inhibited and tissue repair proceeds more slowly. Leithauser demonstrated that patients permitted to rise early following surgery regain their normal vital capacity in two to seven days while those kept in bed require seven to fourteen days. Certainly it is unphysiological to place tissues at rest if their circulation is thereby diminished and slowed. If circulation is slowed, healing is delayed, clotting is facilitated and embolism becomes likely. If disuse causes tissues to lose their full functional purpose, stimulate them and prevent this loss by assigning them their physiological task early in surgical recovery.⁴⁵ True, early rising presupposes certain surgical rules, namely, adequate pre- and postoperative care, careful hemostasis, accurate, gentle wound approximation with well chosen sutures, asepsis and psychic fortification. Early rising is defined as standing or walking in the first twenty-four postoperative hours. Patients may require encouragement and assistance in arising from bed as soon as their postoperative recovery permits. Careful expression of air from the peritoneal cavity at the time of peritoneal closure reduces reaction from this source when the patient arises.

The virtues of early rising are: (1) accelerated healing of tissues, (2) reduced disruption of the wound, (3) minimal thrombic and emboli formation, (4) less gastric and intestinal distention, (5) fewer bladder complications, (6) fewer enemas, (7) reduction in the amount of nursing care needed, (8) greater opportunity for self-help by the patient, (9) improvement of the patient's morale, (10) less asthenia, and (11) shortened hospital stay with resulting economy.⁴⁶

Certain surgical situations or circumstances preclude early rising. Some of these conditions include: (1) fulminating peritonitis, (2) advanced cardiac disease, (3) pancreatitis, (4) hemorrhage not surgically controlled, (5) extensive phlebitis, (6) advanced cachexia and/or jaundice, and (7) large drains and/or temponades.²⁴

Postoperative Complications. Complications that develop postoperatively generally reflect upon the care and foresight of the surgeon. It is his duty to anticipate the complications that may occur and circumvent them. Complications arise mainly from trauma which may be mechanical, infectious, chemical or psychic in nature.¹ The surgeon who operates with minimal trauma will in turn minimize subsequent complications. It is wiser to be adept at preventing complications than skilled in their treatment.

Trauma of mechanical origin accounts for most surgical complications. The more prevalent causative factors are failure to practice scrupulous hemostasis, exposing serosal surfaces and allowing them to become cool and dry, blunt dissection, mass ligation of tissue, indiscriminate crushing of blood vessels, rough handling of other tissues, tension upon visceral structures, prolonged mechanical retraction, allowing hollow viscera to become overdistended and strangulation instead of approximation in closing tissue layers. These surgical indiscretions give rise to shock, pain, distention, nausea, vomiting, ileus, thrombosis, embolus, urinary retention, etc. The

surgeon must be gentle while he executes his task with dispatch.

Trauma of an infectious origin may arise at the site of surgery from whence it may be disseminated elsewhere or it may be introduced into the surgical area and other sites from an external source. If infection is present, endeavor to limit its spread and microscopically identify by smear the causative organism. Frequently, smears from an apparently clean area may reveal organisms that bode harm unless promptly dealt with. In every case endeavor to combat a known causative organism not a group of unfavorable symptoms. Infection in the abdominal cavity when local calls for drainage; when not localized it probably defies drainage. It is necessary to mention the superior surgical results obtained at the Jackson Clinic by the local use of sulfanilamide and sulfathiazole. As much as 5 to 15 Gm. may be placed in grossly infected peritoneal spaces and frequently closed without drainage. It is also well to note the apparent catalytic effect of sulfathiazole and sulfadiazine when administered simultaneously. The sulfa drugs and penicillin are effective surgical handmaidens but they permit no surgical liberties.^{14,47}

Trauma of chemical origin manifests itself mainly by changes in acid-base, nitrogen, water and electrolytic balance. In the body sodium ions make up the chief base and chloride ions are the chief acid radicals. Vomiting can and often does produce alkalosis and is relieved by adequate salt and water. Starvation, diabetes mellitus and loss of intestinal secretions may produce acidosis which calls for glucose, salt, water and at times insulin. Blood chemistry determinations are helpful in regulating these postoperative metabolic disorders.

Trauma of psychic origin includes all the mental changes that surgery and its attended rigors produce. This may vary from fear to a true psychosis. Avoid when possible operating persons who feel they "will not get well." Do not forget that

many psychotic persons subject themselves willingly to surgery and, unless wary, the surgeon may unknowingly "fix" such a psychotic aberration. Cutler has aptly stated that one cannot treat the body well unless one also treats the mind.

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THE PREOPERATIVE AND POSTOPERATIVE CARE IN MAJOR COLONIC SURGERY*

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THE surgeon who would operate upon the colon is confronted with several difficulties which make his work fraught with exceptional danger: (1) Most major surgery of the colon is performed for cancer with its concomitant tendency to debilitation. (2) The colon is filled with a large number of virulent bacteria. (3) The ramifications and interanastomoses of blood vessels supplying the colon are much less free than is the case with the stomach or small intestine. (4) A large proportion of colonic patients are elderly and in poor general condition; and (5) many colonic patients are partially or completely obstructed when first seen, particularly those with sigmoidal lesions.

All these factors add up to the result that many, if not most colonic patients, are subjected to radical and shocking surgery in the face of lowered resistance. Obviously, then, pre- and postoperative care must become equally important with a competent technic. It is the purpose of this paper to present a workable regimen which will yet be flexible enough to permit of modification according to individual circumstances.

PREOPERATIVE CARE

In Absence of Obstruction. In preparing an unobstructed patient for colonic surgery, several desiderata should be fulfilled: (1) The bowels should be empty; (2) peristalsis should be quieted at time of operation; (3) the cardiovascular condition should be as satisfactory as possible; (4) the patient should be well hydrated; and (5) body chemistry, particularly the protein, should be at normal levels.

It takes about five days to empty the

bowel satisfactorily, and this is done last, following the patient's general workup or simultaneous with it. In addition to a thorough history and physical examination including, of course, sigmoidoscopy and biopsy if possible, x-ray studies are done. These consist of flat plate and barium enema followed by a double-contrast air-injection picture. Unless definitely indicated, barium is not administered by mouth, as this occasionally results in obstructing an otherwise unobstructed lesion. If the neoplasm is above the reach of the sigmoidoscope, the roentgenologist will often be able to give an exact localization, which is important in planning the operation. An estimate of the cardiac condition is made, including electrocardiographic readings when indicated. Blood studies are also done as indicated, but always include the following:

1. Complete count
 2. Cephalin flocculation test
 3. Blood chlorides
 4. Blood urea
 5. Blood creatinine
 6. Blood sugar
 7. Total protein
(A-G ratio)
 8. Hgb.
 9. Hematocrit
- } mg. per 100 cc.
} Gm. per 100 cc.

These findings, together with other data, are recorded on a "Colon Sheet."

It will almost invariably be found that the total protein is low and strenuous efforts are made in the preoperative period to obtain a level of 6.5 Gm. per 100 cc. or higher.

If this level cannot be reached, it is not considered an absolute bar to operation

* From the Surgical Service of Dr. Ottokar Tenopir, Kings County Hospital, Brooklyn, N. Y.

but it is believed that the risk is definitely increased. Means adopted for increasing the plasma protein level are: (1) High protein intake by mouth, particularly beefsteak if obtainable; (2) enzymatic hydrolysate of casein and pancreas* 1,000 cc. intravenously daily; (3) oral amigen 2 oz. three times a day usually in grapefruit juice. It is found that although many patients complain about the flavor of oral amigen, they will take it when the necessity is explained; (4) plasma or transfusion as indicated, considering also the degree of anemia.

Other chemical defects are handled in the usual manner; diabetes is treated as such but with insulin rather than by reduction of carbohydrates. If the glucose imbalance is marked, the treatment should be under the control of a competent internist. Chlorides are easily raised by raising the salt intake. If the patient is vomiting, normal saline solution is administered intravenously, but this is ordinarily not the case with unobstructed patients.

To accomplish the objects discussed above, orders are written approximately as follows, but with due regard to the exigencies of the individual case:

1. High protein, high carbohydrate, low residue diet.
2. Multivitamin tablets 2 t.i.d.
3. Type blood (and cross-match 1,000 cc.)
4. Amigen 1,000 cc. intravenously daily.
5. Amigen oral—2 oz. in fruit juice t.i.d.
6. Total plasma protein daily (see discussion of Van Slyke test later in this paper.)
7. Electrocardiogram (if indicated).
8. Transfuse (if indicated).
9. Sulfasuxidine 2 Gm. initial dose followed by 1 Gm. every four hours.
10. Insulin, digitalis, etc., (if and as indicated.)

* The product used in our cases is Amigen, manufactured by Mead Johnson & Co.

Next, starting five days preoperatively, the following orders are written:

First day—Licorice powder drams 2 at night.

Second day—6 A.M. magnesium sulfate 50 per cent—1 oz.

Third day—6 A.M. magnesium sulfate 50 per cent— $\frac{1}{2}$ oz.

Fourth day—6 A.M. magnesium sulfate 50 per cent— $\frac{1}{2}$ oz.

Fifth day—(day before operation)

6 A.M. castor oil— $1\frac{1}{2}$ oz.

6 P.M. paregoric drams 1

6 P.M. 1 pint tap-water enemas until clear

Morning of operation:

1. 1,000 cc. saline intravenously before going to operating room.
2. Catheterize and leave catheter in place.
3. Levine tube in stomach.
4. Preoperative medication.
5. Transfusion of citrated blood.

Preoperative Care When Patient Is Obstructed. The presence of partial or complete obstruction profoundly alters the situation. Not only does surgery in the presence of obstruction offer technical difficulties in the shape of a distended bowel and sometimes a vomiting patient, but also the bowel proximal to the point of obstruction contains organisms of vicious virulence and the walls of the gut are greatly devitalized so that needle holes do not close tightly and suture lines do not hold so well. It is, therefore, of the greatest importance to relieve the obstruction by medical means if at all possible prior to surgery. To this end, Wangenstein suction is instituted from above and high colonic irrigations two to three times daily from below. In addition, sulfadiazine is administered intravenously with the idea that if some of the obstructing mass is inflammatory, as it ordinarily is, the exhibition of potent chemotherapy may aid in reducing its size. Very occasionally, an obstructing lesion in the upper rectum may be by-

passed by a small catheter inserted under direct vision through a proctoscope.

It is quite astonishing how often a markedly distended abdomen will be decompressed by these maneuvers. It should be borne in mind, however, that the Wangensteen suction is intended only to control vomiting and small intestinal distention; neither it nor the Miller-Abbott tube will ordinarily be effective in reducing a distended colon.

If it has been possible to overcome the obstruction by the means outlined above, the bowel is then emptied as well as possible from below (the use of cathartics is rather dangerous here and should be subjected to careful judgment). It is usually the procedure of choice to perform a two-stage operation in these patients, the first stage being one form or other of colostomy; and in any case, primary anastomosis of the left colon is not done in any patient even slightly obstructed.

The body chemistry is investigated and corrected as nearly as possible in the manner described for unobstructed patients. Sometimes, however, a surgical decompression must be done too soon to permit an ideal workup.

POSTOPERATIVE CARE

Having performed an extensive operation—and colonic surgery for carcinoma should be extensive—the next problem is to keep the patient alive through three primary dangers: shock, pneumonia and peritonitis, of which the last is fortunately becoming uncommon.

At the time of operation, 10 Gm. of crystalline sulfanilamide are often placed about the suture line or area of possible contamination. Sulfathiazole is not used because of its tendency to cake. A transfusion of at least 500 cc. and sometimes 1,000 cc. is given during and following the operation.

Shock is to be detected and treated in its infancy—long before blood pressure drop ensues. To this end, hematocrit readings are checked frequently by the Van Slyke

copper sulfate method and plasma is given when indicated. Continuously rising hematocrit indicates imminent shock and continuously dropping hematocrit indicates hemorrhage.

Pneumonia is to be anticipated and combatted by the use of penicillin, early ambulation, frequent changes of position and proper aeration of lungs.

Peritonitis is combatted by careful operative technic and the use of sulfonamides, with emphasis upon the former. It is believed that the sulfonamides are more effective than penicillin for colonic bacteria.

Fluid and electrolyte balance are also to be maintained.

These desiderata are translated into the following more or less routine orders which are, of course, modified to suit the individual case:

1. Fluids, at least 3,000 cc. in twenty-four hours, divided thus:

Amigen: 1,000 cc.

Glucose 5 per cent in normal saline: 1,000 cc.

Glucose 10 per cent in water: 1,000 cc.

2. Vomitus or Wangensteen drainage to be measured and this amount added to the requirement of saline solution.

3. Apply Wangensteen suction to Levine tube which is already in place.

4. Oxygen tent. (This is not routine but is utilized at the slightest provocation.)

5. Turn patient from side to side every few minutes.

6. Out of bed in wheelchair for fifteen minutes within twenty-four to forty-eight hours if possible. (Judgment as to this rests on condition of patient, method of suturing wound, etc.)

7. Sodium sulfadiazine intravenously—6 to 7 Gm. in twenty-four hours until peristalsis returns and patient is accepting food by mouth. (After this time sulfasuxidine may or may not be given.)

8. Penicillin 50,000 units intramuscularly stat—then 30,000 units every three hours (until danger of pneumonia is considered slight).

9. Daily blood sulfa level (to be maintained between eight and 12 mg.)

10. Morphine sulfate gr. $\frac{1}{6}$ every four hours p.r.n.; (as little as possible.)

11. Van Slyke test every two to four hours on the first day, then daily.

12. Moderate Trendelenburg for six hours (for pulmonary drainage) then gradually flat and changed to semi-Fowler with pillow under each axilla.

13. No enema for five to six days, and then only in small amounts.

14. Insert rectal tube for 3 inches only.

In cases of clamped colostomies, the clamp is customarily removed from the proximal (working) opening in forty-eight to seventy-two hours, but there is no objection to removing it in thirty-six hours if distention or other symptoms make it desirable.* If a distal opening is present and clamped, as in a first stage Lahey operation, this clamp remains in place until it falls off, which is usually in about a week.

PRIMARY ANASTOMOSIS

In the right colon, primary anastomosis is done routinely, except in cases of emergency in which it is imperative to stop the operation as soon as possible. Ascending colectomy is accompanied by ileotransverse colostomy and the suture line is ordinarily, though not invariably, decompressed by either a proximal ileostomy after the method of Witzel or a Miller-Abbott tube inserted a few days in advance in order to permit it to reach the ileum.

In the left colon, the dangers of primary anastomosis are not inconsiderable, since there is likely to be at least some degree of obstruction and the resultant devitalizing effect on the bowel wall may permit leakage through suture holes if not actually through the line of anastomosis. If, however, obstruction can be completely and definitely overcome for a period of two weeks by means of a proximal colostomy, primary anastomosis is often feasible.

* With the use of a Daniel clamp² decompression is attained immediately.

CHEMOTHERAPY

Penicillin is a powerful aid against pneumonia, but is inferior to the sulfonamides in combatting colonic bacteria. For this reason, penicillin is administered only after operation and the sulfonamides both before and after surgery.

As soon as peristalsis has started and stools are being passed, suction is gradually discontinued and feedings by mouth are begun. This is usually in about three to four days. At this time also intravenous sulfadiazine may be discontinued and replaced, if desired, by sulfasuxidine orally.

VAN SLYKE TEST

This test, known also as the copper sulfate test, is one of the most useful laboratory procedures yet devised. By means of a comparatively simple maneuver performed in five minutes in the ward by the intern, the following information is obtained: plasma protein, hematocrit and hemoglobin.¹¹

ANESTHETIC

It is believed that intrathecal procaine in competent hands is the anesthetic of choice. However, in the absence of a trained anesthesiologist, who can both administer and take complete charge of the progress of anesthesia, general anesthetics are resorted to. For critically ill patients who are being subjected to emergency surgery for obstruction, local anesthesia is often utilized. In this regard, it has been our experience that if the line of skin incision is injected intradermally with 1 per cent novocaine, a minimal quantity of $\frac{1}{4}$ per cent novocaine will suffice for the remainder of the operation. In order to lessen the number of external skin punctures, the skin may be infiltrated by inserting the needle subcutaneously at one end of the proposed line of incision and creating a series of wheals from the under surface.

EVISCERATION

This is fortunately a rare complication of colonic surgery. It is believed that while

alone and to avoid the temptation to add blood plasma, sulfonamides or other preparations to the infusion containing the hydrolysate.

SUMMARY

1. A basic regimen has been presented for the pre- and postoperative care of colonic surgery.

2. Views are presented on the subjects of primary anastomosis of the left colon, chemotherapy, the Van Slyke test, choice of anesthetic, postoperative evisceration and emergency colostomy.

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CRYPTITIS is a state of inflammation in a crypt of Morgagni. This will usually precede a papillitis. Papillitis is an inflammatory reaction of a papilla, usually associated with edema and hypertrophy.

From "Ambulatory Proctology" by Alfred J. Cantor (Paul B. Hoeber, Inc.)

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